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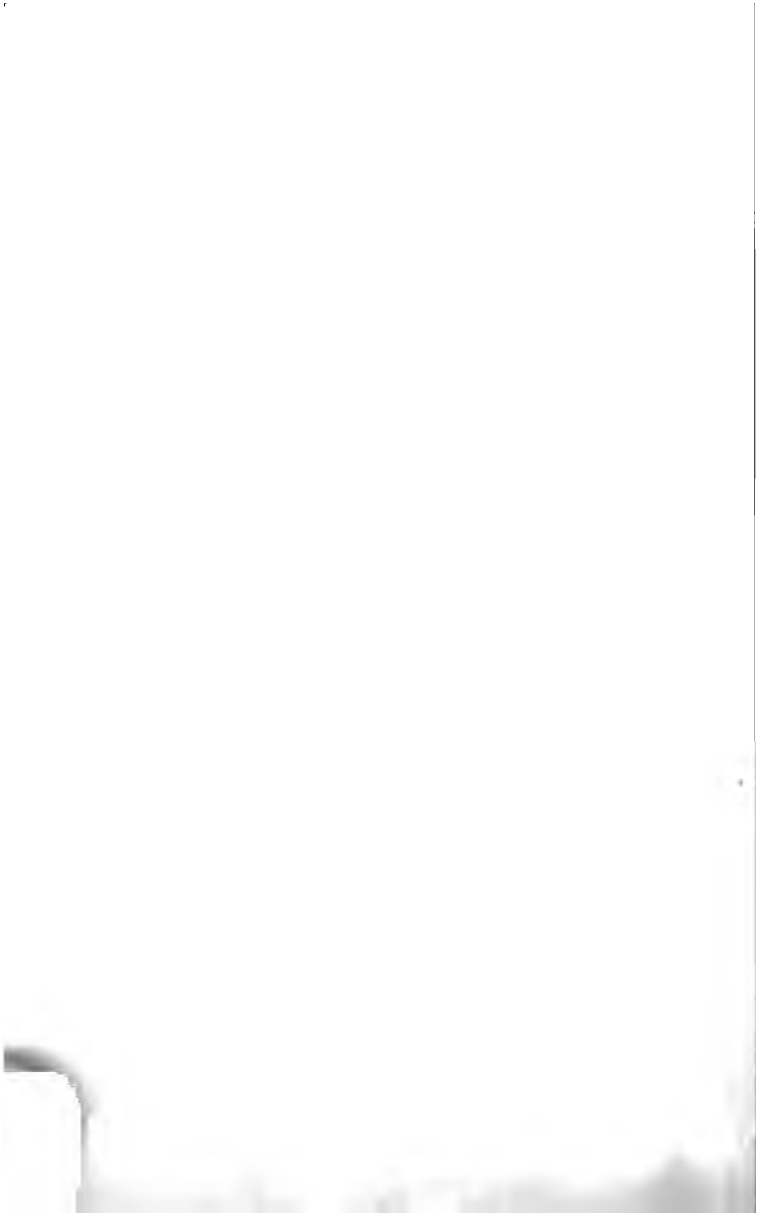

AUTOMOBILE CATECHISM
AND
REPAIR MANUAL

A Series of Questions and Answers Covering the Construction, Care, and Operation of Automobiles

ALSO

Complete Instructions for Locating Troubles and Making Adjustments and Repairs of All Kinds

PREPARED EXPRESSLY FOR

Owners, Chauffeurs, Garage Men and Automobile Machinists

BY

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INTRODUCTION

THE phenomenal development of the automobile within the past few years has resulted in the creation of new branches of skilled labor of the highest grade, not only in the design and construction of this useful and valuable machine, but also in its care and operation. The safe and successful management of the swiftly moving auto, as it threads its way through the crowded street, or rapidly covers distance upon the highway, calls for skill, intelligence, and a thorough knowledge of the machine in all its details. With a view of supplying this information in a condensed, and at the same time clear and accurate form, the authors have prepared this little book in which the autoist can find without delay just the instructions needed for guidance in the repair, adjustment and operation of his machine.

For convenience the work is divided into two parts. Part I comprises over four hundred questions and answers, covering all parts of the automobile with respect to construction, care and operation, and reference tables with charts, illustrating all parts in minute detail. The questions and answers are arranged alphabetically so that the desired information may be easily obtained.

Part II is devoted entirely to repairs. It is one thing to know how to make repairs and adjustments, another to know what the trouble is. This book takes nothing for granted, but proceeds in a

systematic manner to show how to locate a cause of trouble. Once the offending part is determined, the best method of repairing it is graphically described and illustrated. The methods of adjustment and repair of all the widely used types are explained. The last chapter will be found particularly valuable to the man who wishes to keep his tire bills low, showing the various tire ailments, their cause and their cure.

QUESTIONS AND ANSWERS.

A.

Ques. 1. Mention some of the inconveniences connected with the use of the Acetylene light?

Ans. It contains impurities which endanger health when burned in a closed room. Carbon dust gets into the burners and clogs them; sometimes causing explosions.

Ques. 2. What should be done with an Acetylene lamp system in order to get satisfactory service from it?

Ans. Strict cleanliness should be maintained at all times, and the various parts should be examined and replaced from time to time as necessary.

Ques. 3. How is the electrolyte for storage battery cells made?

Ans. By pouring sulphuric acid into distilled water until the specific gravity is 1.12; then allow the solution to cool until its temperature is about 60 degrees.

Ques. 4. What is an electrical accumulator?

Ans. The storage battery is an accumulator of electrical energy, and is used for driving the electrically propelled car.

Ques. 5. Define the word Acceleration.

Ans. The increase of motion; the time period of mutation in velocity.

Ques. 6. What is an acetometer?

Ans. A graduated hydrometer used to ascertain the strength of acetic acid.

Ques. 7. What is an active coil, or conductor?

Ans. One that is conveying an electric current.

Ques. 8. What are the leading features of the Adams motor car?

Ans. The crank shaft is mounted vertically, and is stationary, the five cylinders revolving around it. The drive from the revolving cylinders to the gear set is through a bevel gear attached to the base of the revolving crank case, and which meshes with a bevel gear on one of the transverse shafts of the transmission.

Ques. 9. What rule should govern the diameter of admission pipes for explosive motors?

Ans. The internal diameter of the admission should not exceed one-fourth the diameter of the motor cylinder.

Ques. 10. How may the diameter of admission valve opening be determined?

Ans. Multiply the bore of cylinder in inches by the stroke in inches, and by the number of revolutions per minute and divide the product by 15,000.

Ques. 11. What should be the lift of a flat seated valve, relative to its diameter?

Ans. The lift should be one-fourth the diameter of the valve.

Ques. 12. Does the rule given in answer to Ques. 10 for valve diameter apply to all types of valves?

Ans. No, only to those which are mechanically operated. For atmospherically operated valves, substitute 12,750 instead of 15,000 for the divisor.

Ques. 13. Give the composition of air.

Ans. By weight, oxygen 77 parts, nitrogen 23 parts. By volume, oxygen 21 parts, nitrogen 79 parts.

Ques. 14. How many, and what are the methods in use for cooling the cylinders of explosive motor engines?

Ans. Two; the air system, and the water system.

Ques. 15. Describe the air cooling system.

Ans. A rotary fan driven by the engine directs a constant current of fresh unheated air upon the outside surface of the cylinders.

Ques. 16. What proportion of air to gasoline is required for the best explosive mixture?

Ans. 8,000 volumes of air to 1 volume of liquid gasoline.

Ques. 17. Define gasoline considered as a mechanical mixture.

Ans. It consists of several hydrocarbon distillates, in which the compound hexane is supposed to be the major portion.

Ques. 18. Give the formula for hexane.

Ans. $C_6 H_{14}$.

Ques. 19. What, then, would be a final expression of complete combustion of hexane?

Ans. $2\ C_6\ H_{14} \times 19\ 0_2 = 12\ CO_2 + 14\ H_2O$

In which C = Carbon
H = Hydrogen
O = Oxygen

Ques. 20. If V = the velocity of the car in feet per second, and A = projected area of the front of the car in square feet, how may the horse power required to overcome the air resistance be found?

Ans. By use of the following formula:

$$H\,P = \frac{V^3 \times A}{240{,}000}$$

Ques. 21. How many kinds of alcohol are there?

Ans. Two; methyl, or wood alcohol $C\ H_4\ O$, and ethyl, or grain alcohol, $C_2\ H_6\ O$.

Ques. 22. Is wood alcohol practicable as a fuel for internal combustion engines?

Ans. It is not, owing to corrosive action on the cylinders.

Ques. 23. What is denatured alcohol?

Ans. Pure grain alcohol, diluted as follows: To 100 volumes of alcohol are added 10 volumes of methyl, and one-half of one volume of benzine; or two volumes of methyl, and one-half volume of pyridine bases.

Ques. 24. As compared with gasoline, is alcohol a desirable fuel for internal combustion motors?

Ans. In some respects it is; as, for instance, the combustion is complete, the exhaust is practically odorless, and there is far less noise. On the other hand, a much larger quantity of alcohol is required in proportion to horse power developed than with gasoline, and a much greater degree of compression is required with alcohol as fuel.

Ques. 25. What is the ratio of air to alcohol vapor required for complete combustion?

Ans. From 10 to 25 volumes of air to 1 of alcohol.

Ques. 26. What is aluminum?

Ans. A soft, ductile, malleable metal, of a bluish white color, non-corrosive, T. S. about one-third that of iron; the lightest of all useful metals, except magnesium.

Ques. 27. What is aluminoid?

Ans. Alloy composed of, by weight, 60 parts aluminum, 30 parts tin, and 10 parts zinc. T. S. 18,000 lbs., suitable for crank chambers, gear cases, etc., being light, extremely ductile, and readily machined.

Ques. 28. What is the function of an ammeter?

Ans. To measure the volume of the electric current flowing in a circuit.

Ques. 29. What is an ampere?

Ans. The unit of electric current flow.

Ques. 30. What is the meaning of an ampere-hour?

Ans. In connection with a storage battery

an ampere hour denotes the capacity of the battery for current, as for instance a battery that will keep a 2 ampere lamp burning for 8 hours is said to have a 16 ampere hour capacity.

Ques. 31. What is an armature?

Ans. The rotating part of a dynamo, or electric motor. Two types are in general use with automobiles, viz., the shuttle type, and the slotted type of armature.

Ques. 32. What is autogenous welding?

Ans. The welding, or rather melting together of metals by means of the oxyacetylene flame, the temperature of which is 6,300 degrees F.

Ques. 33. What is an auto-meter?

Ans. An instrument for recording the speed of an automobile or other vehicle in miles per hour.

Ques. 34. Name the various types of automobiles.

Ans. Gasoline cars—Runabout, Touring Car, Light Car with detachable Tonneau, Stanhope, Roadster. Electric—Runabout, Parktrap, Phaeton, Brougham, Depot Bus, Light Delivery Wagon.

Ques. 35. Which one of the axles of an automobile is ordinarily used for driving the machine?

Ans. The rear axle.

Ques. 36. What is a dead axle?

Ans. An axle which carries weight only.

Ques. 37. What is a live axle?

Ans. An axle containing parts that turn the wheels, in addition to carrying weight.

Ques. 38. What is a floating axle?

Ans. A special type of live axle in which the shaft that turns the wheels is independent of the axle proper.

B.

Ques. 39. What is meant by the term back-firing?

Ans. An explosion or impulse which forces the fly wheel of a motor suddenly backwards, that is in the opposite direction to its proper rotation.

Ques. 40. What causes back firing?

Ans. Back firing may be caused by (1) the explosion of an accumulation of unburned gases in the exhaust muffler, (2) a weak mixture, (3) an overheated combustion chamber, (4) advancing the ignition point too far ahead when the motor is running slow under heavy load, (5) deposits of carbon (soot) in combustion chamber, which may become incandescent, causing premature ignition.

Ques. 41. How many types of ball bearings are in use on automobiles?

Ans. Three—thrust, cone, and annular.

Ques. 42. Why are thrust bearings so called?

Ans. Because they are intended to sustain end thrust. For this reason they require to be correctly machined.

Ques. 43. Is the adjustable cone bearing a good bearing for automobiles?

Ans. It usually gives excellent results, except under heavy loads.

Ques. 44. Which type of ball bearing is probably the best for all kinds of auto service?

Ans. The annular, consisting of three elements, two races, and the balls.

Ques. 45. What percentage of the balls are under load at any one time, in the annular type?

Ans. Only 30 per cent.

Ques. 46. Should ball bearings be lubricated?

Ans. They should.

Ques. 47. How is a dry battery usually made up?

Ans. A zinc cell forms the negative element, and the electrolyte is generally a jelly-like compound containing sal-ammoniac, chloride of zinc, etc. The positive element, or carbon, is enclosed in a sack containing dioxide of manganese and crushed coke, which are the depolarizing agents of the battery.

Ques. 48. What is a primary battery?

Ans. Any battery, either dry or wet, which generates electric current within itself.

Ques. 49. What type of primary battery may be used for charging a small storage battery in the absence of direct current?

Ans. One of the closed circuit type, using zinc and carbon electrodes in a 20 per cent so-

lution of sulphuric acid and water, with nitrate of soda as the depolarizing agent.

Ques. 50. What is the voltage usually required in an ignition system?

Ans. Usually 6 volts.

Ques. 51. How are the batteries connected?

Ans. Either in series, or multiple.

Ques. 52. Describe the series-multiple connection.

Ans. When two or more sets of batteries connected in series are, as sets joined in multiple, the whole is in series-multiple.

Ques. 53. Describe in general terms the construction of the storage battery as used in ignition service.

Ans. It is usually of the lead, lead type, the electrolyte being sulphuric acid and water, having a specific gravity of 1,200. The positive and negative plates or elements are grids made of lead alloy, stiffened with antimony.

Ques. 54. Mention some of the troubles that attend storage batteries in service.

Ans. Hardening of negative elements, local action, buckling of plates, sulphation, reversal of negative elements, disintegration of grids, broken jars, loss of capacity, short circuits.

Ques. 55. How is loss of the electrolyte by evaporation compensated for?

Ans. By adding distilled water to the cells from time to time.

Ques. 56. How is the proper quantity of water to be added to the cell determined?

Ans. By means of an instrument called a hydrometer.

Ques. 57. Aside from ball bearings, how are the other bearings of an automobile classified?

Ans. In two general classes—hard and soft.

Ques. 58. Of what metals are hard bearings composed?

Ans. Either brass or bronze.

Ques. 59. Give the composition of soft bearings.

Ans. They contain a large proportion of tin, or lead, and a small percentage of copper. Babbitt metal, anti-friction metal and white metal constitute such alloys.

Ques. 60. How may the brakes on automobiles be classified?

Ans. Into three classes, as follows: Hub or rear wheel brakes, transmission and differential gear brakes. They are either single or double acting, foot or hand operated, and of the band, block, or expanding ring types.

Ques. 61. Mention some of the advantages of the expanding brake.

Ans. (1) It is less liable to drag upon the drum, (2) it is easily made double acting, (3) it has more braking power for a given pressure, (4) the friction surfaces are better protected from mud and grit.

Ques. 62. Describe the action of the differential brake.

Ans. It usually consists of two drums, one of which is fastened to each of the large gears

of the differentials. The straps and bands encircling these drums are tightened by pedal, or lever, in the usual manner.

Ques. 63. What is the function of an equalizer in connection with an automobile brake?

Ans. It causes the same pressure to be applied to both brakes.

Ques. 64. What would be the result if this pressure were not equally applied to the brakes?

Ans. Side slip, or "skidding."

Ques. 65. Describe the sprag brake and its use.

Ans. A sprag is a strong steel bar connected at its forward end to some point of the under part of the frame, while its rear end is pointed and hangs suspended by a chain, by means of which it may be dropped to the ground in case of emergency, thus preventing the car from running backwards down hills.

Ques. 66. Are there any other forms of sprag brakes?

Ans. Yes; a ratchet wheel and pawl may be arranged, either on the rear axle, on the differential, or within the change-speed gear box, thus rendering backward motion of the car impossible when the brake is in action.

Ques. 67. How should the sprag brake be used when ascending dangerous hills?

Ans. It should be set so as to act immediately in case the car stops.

Ques. 68. Among the various parts of an

automobile how should the brakes be considered?

Ans. The brakes come next to the motive power in importance, and freedom from disaster depends upon the brakes being kept in good condition and properly adjusted.

Ques. 69. How may it be known whether they are in good condition or not?

Ans. By frequently testing them while the car is in motion, by applying them until the car slows down or stops.

Ques. 70. How should the brakes be applied in ordinary service?

Ans. Except in case of emergency, the application should be gradual, reducing the speed of the car without locking the wheels.

Ques. 71. In case the wheels become locked while descending a hill what is to be done?

Ans. Release the brakes until the wheels again revolve, then reapply gradually.

Ques. 72. What care should the brakes receive?

Ans. They should be examined at regular intervals. If the lining is worn it should be replaced with new lining. Toggle joints and adjusting nuts should be inspected, and any looseness taken up. The shoes of internal expanding brakes should be renewed when worn.

Ques. 73. In case a chain should break how may the car be driven?

Ans. By the other chain, provided the idle sprocket is secured from revolving.

Ques. 74. How may leakage of the water circulating pump be repaired?

Ans. If at the ground joint, insert a stiff paper gasket dipped in lubricating oil. If the leak is around the pump spindle use asbestos cord, or a strand of hemp rope soaked in vaseline and graphite or tallow.

Ques. 75. Describe the proper method of cranking an explosive motor to start it.

Ans. Adjust the crank to start against the compression, then give a quick pull upward. Do not attempt to turn the crank all the way around.

Ques. 76. If, at any time, oil or grease cannot be obtained for filling the differential casing, what is to be done?

Ans. Beeswax may be used as a substitute.

Ques. 77. Should the gasoline pipe get broken how may it be temporarily repaired?

Ans. By forcing a short piece of rubber tubing over the broken ends. If the hole is only small, squeeze a piece of soap into it, and secure it by tying a piece of soaped rag around it with a piece of twine.

Ques. 78. Should one of the cylinders miss some of its explosions at intervals, how may it be located?

Ans. Stop the machine and then touch each one of the cylinders with the business end of a match; those cylinders that have been doing the work will be hot enough to ignite the match, while the missing cylinder will not.

Ques. 79. How may refractory nuts be loosened?

Ans. Hold a piece of red hot iron near them for a few minutes. This will expand the nuts.

Ques. 80. If a motor refuses to start readily what may be done to assist it?

Ans. Tie a small bunch of waste with a wire close to the air intake, and saturate it with gasoline.

Ques. 81. How may a broken rod, or link in the steering gear be temporarily repaired?

Ans. Fasten a rod or a piece of gas pipe against the link, winding the wire the entire length of the rod.

Ques. 82. How may broken trembler blades be temporarily repaired?

Ans. By cutting corset steels to the proper length, and rivet them with the platinum button from the broken blade through the hole which is punched near the end of the steel. A piece of the main spring of a clock also makes a good blade.

Ques. 83. Enumerate some of the various causes of break-downs.

Ans. Soot or grease on the spark plug; defective insulation of the spark plug; points of the spark plug too far apart; contacts badly corroded; broken wires; loose battery terminals; leaky valves; seized piston, or bearing; broken valve stem, or valve spring; batteries exhausted; defective packing.

C.

Ques. 84. Mention some of the symptoms of carbon deposit.

Ans. Back-firing, and knocking in cylinders, motor showing plenty of power at high speeds, but deficient in hill climbing.

Ques. 85. What should be done when these symptoms appear?

Ans. Take off the cylinder heads and scrape off the carbon deposit from top of pistons and inside of cylinders.

Ques. 86. What is the function of the carbureter on an explosive motor?

Ans. To correctly prepare the mixture of air and gasoline before its admission to the cylinder.

Ques. 87. How many types of carbureters are there in use?

Ans. Four, as follows: (1) The mechanical; (2) mechanical, with a gasoline puddle in the air passage; (3) the automatic; (4) automatic with a gasoline puddle in the air passage.

Ques. 88. Describe in brief the action of each.

Ans. In type (1) the passages are opened and closed by mechanism, the passages remaining the same until changed by the operator. In type (2) a basin filled with gasoline is located in the air pipe, which serves to add a certain quantity of gasoline at all suctions, but neither of these two types are entirely satisfac-

tory under the varying conditions of high speed, slow speed, climbing hills, or diminished suction. Type (3) takes a portion of its air through a fixed opening, and a portion through an auxiliary opening which is controlled by a valve and coiled spring. This type gives better service. In type (4) the action of the gasoline puddle is similar to that of type (2) having the same objectionable features.

Ques. 89. In what other ways are carbureters classified?

Ans. According to the principles of their action; as for instance, the surface carbureter, in which the air is either passed over the surface of the volatile liquid, or circulated around a gauze wicking or metallic surface saturated with such liquid. Second, the filtering carbureter, in which air is forced under suction through a body of the liquid from bottom to top, thus absorbing particles of its substance. Third, the float feed carbureter, in which the liquid hydrocarbon is sprayed or atomized through a minute nozzle and mixed with a passing column of air.

Ques. 90. What are some of the characteristics of the surface carbureter?

Ans. While it is the most economical form still it is very irregular, and erratic in its action, requring constant attention.

Ques. 91. Describe in brief the construction and action of the float feed carbureter.

Ans. A small gasoline receptacle contains a

hollow metal, or a cork float arranged to control the gasoline supply from the tank, or reservoir, and a tube in which is located a nozzle in communication with the gasoline receptacle. This is the mixing chamber. The gasoline level is maintained about one-sixteenth of an inch below the nozzle opening in the mixing chamber. The gasoline is drawn from the jet in the mixing chamber by the vacuum created by the intake stroke of the motor piston, and mixes with the air supply to be drawn into the cylinder in the form of an explosive mixture.

Ques. 92. How should carbureters be inspected?

Ans. The float valve should be inspected for leaks as follows: First, close the main gasoline valve, then unscrew the washout plug below the needle valve and remove any dirt or bits of waste that may have passed the strainer. Another method is to open the top of the float chamber and take out the float and needle valve, then wash out with gasoline. If a light is necessary in making this inspection, use an incandescent electric, as there is danger in using any other.

Ques. 93. Describe the double chain drive.

Ans. The driving axle is solid and stationary. To the inside of the spokes of each driving wheel is bolted a large sprocket wheel, while a counter shaft divided at its central portion is carried by the chassis a short distance ahead of the driving axle. The two inner ends of this

counter shaft connect with the differential gear, while the two outer ends carry each a small sprocket wheel over which the chains travel.

Ques. 94. Describe the single chain drive.

Ans. The rear or driving axle revolves, and upon it the large sprocket is secured. The small sprocket is carried by the engine shaft which also carries the change speed gear, while the differential gear is located on the rear axle.

Ques. 95. How often should the chains be cleaned?

Ans. At least once a month.

Ques. 96. How may this be done effectually?

Ans. Remove the chains and throw them into a vessel containing kerosene, leaving them there for 10 or 12 hours, after which wash with gasoline. After the chains are dry, soak, or boil them in a mixture of beef tallow and graphite.

Ques. 97. What is the function of the change speed gear?

Ans. To enable the chauffeur to increase the speed of the engine without increasing the speed of the driven shaft, or car axle.

Ques. 98. How is this accomplished?

Ans. In some cases by belt, and friction drives. In other cases by sliding gears, individual clutch gears, and planetary gears.

Ques. 99. What is the principle of the planetary gear?

Ans. It consists of a high speed connection for the direct drive, and an arrangement of gears that reduces, or reverses the motion when

one or another drum on which these gears are mounted is held stationary.

Ques. 100. What are the basic principles of friction, and belt and pulley change speed drives?

Ans. The ratio of the driver and the driven is changed by bringing into contact friction discs, or pulleys of varying diameters.

Ques. 101. What is the meaning of the word chassis?

Ans. Applied to automobiles it means the frame, springs, wheels, transmission, in fact all mechanism except the automobile body.

Ques. 101A. What is a circuit breaker?

Ans. A device which acts automatically to break an electric circuit.

Ques. 102. What is the function of a circulating water pump?

Ans. It is supposed to regulate the temperature of the jacket water, but it fails to do this perfectly, for the reason that being driven direct from the motor, it operates with a speed which varies with the speed of the motor, regardless of the speed of the car. In other words the car may be climbing a hill at slow speed while the motor is working at full charge, but getting very little cooling effect from wind pressure, or, on the other hand the car may be running at high speed, with the motor working on a light charge, while the cooling effect of the wind is very great, and the pump is also running at high speed.

Ques. 103. What type of pump is ordinarily used on automobiles?

Ans. The rotary.

Ques. 104. How are clutches usually classified?

Ans. Cone, disc, and band.

Ques. 105. What is the prime object of a clutch?

Ans. To enable the operator to start, and stop the car without having to stop the motor.

Ques. 105A. What is the combustion chamber?

Ans. That portion of the motor in which the gases are compressed, and ignited.

Ques. 106. What are the requirements of a combustion chamber?

Ans. The interior should be as smooth as possible, and kept free from soot or carbon deposits.

Ques. 107. What are the functions of the commutator of the ignition system of a multicylinder gasoline motor?

Ans. (1) To switch the battery current in and out of the electrical circuit at the proper time; (2) to transfer the battery current successively from one coil to another; (3) to vary the point, or time of ignition.

Ques. 108. What care should be given the commutator?

Ans. The platinum contacts should be cleaned at least once a week with fine sandpaper. If of the rotary wiping form, the brass or copper

segments should also be cleaned in the same way. All lock nuts, and adjusting screws should be carefully gone over at the same time.

Ques. 109. What is the function of a compensating or flexible joint?

Ans. To allow for the distortion of the running gear, due to rough roads.

Ques. 110. With gasoline motors what is the allowable compression in lbs. per sq. in.?

Ans. About 85 lbs.

Ques. 111. How high may the compression be raised with the heavier fuels, such as kerosene?

Ans. 250 lbs. per sq. in.

Ques. 112. How may the compression in atmospheres of a motor be calculated?

Ans. Divide the volume of the piston displacement in cubic inches by the volume of the combustion chamber, also in cubic inches, and add one to the result.

Ques. 113. What is the function of a current condenser on an automobile?

Ans. To absorb the static charge of electricity caused by self-induction in the primary coils.

Ques. 114. What is the function of the contact breaker?

Ans. To open the electric circuit at the proper time for the passage of the spark at the points of the spark plug.

Ques. 115. Why is cooling of the cylinders of explosive motors necessary?

Ans. In order to permit of proper lubrication, and also to prevent pre-ignition.

Ques. 116. How many cooling systems are in use?

Ans. Two—viz.—air cooling, and liquid cooling.

Ques. 117. What should be the temperature of the cylinders, for efficient work?

Ans. As near 350 degrees F. as possible.

Ques. 118. What liquids may be used for cooling?

Ans. Alcohol; a light, thin mineral oil; or water.

Ques. 119. What portion of the cylinder wears fastest?

Ans. The side against which the piston is forced by the angularity of the connecting rod.

D

Ques. 120. What are Dalton's laws relative to vapor tension, and quantity?

Ans. (1) The pressure and quantity of vapor that will saturate a given space are the same for the same temperature, whether the space contains a gas, or is a vacuum; (2) the pressure of the mixture of a gas and a vapor equals the sum of the pressures that each would exert if it occupied the same space alone.

Ques. 121. If the cooling water contains lime or alkali, how will it affect the cooling spaces?

Ans. Scale, and solid substances will be deposited inside and prevent proper circulation.

Ques. 122. How may this scale be dissolved?

Ans. Dilute one part of muriatic acid with nineteen parts water, then drain the jacket completely, and pour in enough of the solution to fill the entire cooling space. Allow the solution to remain in the jacket from 8 to 12 hours, then wash out by allowing clear water to run through it.

Ques. 123. How often should this method be applied?

Ans. Once every two weeks, with hard water.

Ques. 124. What is the function of the differential gear?

Ans. To allow one of the driving wheels to turn at a different speed from the other, when necessary, as for instance, in rounding a sharp curve, the outer wheel must travel a much farther distance in the same length of time than does the inner wheel, and if the two wheels were turning the same number of revolutions, one, or both of them would be forced to slip were it not for the differential gear which at such times allows the inner wheel to turn slower.

Ques. 125. What advantage is gained by the use of a distributer with the ignition system?

Ans. By its use any number of cylinders may be sparked from a single coil.

Ques. 126. What precautions should be observed in the operation of gasoline motors?

Ans. Never use a match or small torch while inspecting the carbureter. Do not smoke while filling the gasoline tank. Always carry an extra spark plug on the car. Do not allow the motor to race or run fast when out of gear, but retard the ignition, and throttle the charge when the car is to be stopped for a few minutes. Do not fill the gasoline tank entirely full, but leave a small air space at the top. If the car while running, makes an unusual noise, stop immediately and ascertain the cause. Do not start or stop too suddenly.

Ques. 127. What is a good rule to follow when on the road?

Ans. Drive with moderate speed on the level, slow speed down hill, and wide open throttle for hill climbing, or getting up speed only.

Ques. 128. Why are not large driving wheels more used?

Ans. Because (1) the car is less stable in turning corners; (2) large wheels are much more expensive, also more liable to injury than are wheels of smaller diameter.

Ques. 129. What is a Dynamometer?

Ans. A form of equalizing gear which is attached between a source of power and a piece of machinery, when it is desired to ascertain the power necessary to operate said machinery with a given rate of speed.

E.

Ques. 130. What is meant by the efficiency of an explosive motor?

Ans. The relation between the number of heat units consumed by the motor, and the number of foot pounds of work or energy given out by the motor.

Ques. 131. What proportion of the heat units consumed by an explosive motor are utilized, or given up in actual work?

Ans. About one-fifth.

Ques. 132. How is fuel efficiency of explosive motors considered, relative to that of weight?

Ans. At the present time it is of secondary importance.

Ques. 133. What then, is considered to be of primary importance in the performance of an explosive motor on an automobile?

Ans. To obtain the maximum amount of power from a motor of minimum weight.

Ques. 134. How may the fuel efficiency of a motor be increased?

Ans. By a proper manipulation of the machine, and by a correct adjustment of the valve mechanism.

Ques. 135. What conditions affect motor efficiency?

Ans. The power for weight efficiency increases almost in proportion to increase of speed with high speed explosive motors, but the fuel efficiency decreases with an increase of speed beyond certain limitations.

Ques. 136. How may electricity be generated?

Ans. In several ways, as for instance, mechanically, chemically, and statically or by friction.

Ques. 137. What can be said of the current from a storage battery, and that from a dry battery?

Ans. Current from a storage battery will flow continuously until the battery is exhausted, while current from a dry battery can only be used intermittently, that is, it must have slight periods of rest.

Ques. 138. What is the nature of the current generated by the dynamo, or magneto?

Ans. It is alternating; reversing its direction of flow rapidly.

Ques. 139. How is it changed into a direct current?

Ans. By means of a commutator.

Ques. 140. May any of the forms of electric current enumerated in the answer to question 136 be used in the ignition system of an explosive motor?

Ans. They may, but the static or frictional form is not used on account of its erratic nature.

Ques. 141. What care should be given the electric plant of an automobile?

Ans. Look it over frequently; replace worn wires with new ones; clean out the timer with gasoline, and lubricate with light oil. Examine the storage battery and if brown deposits are

seen at bottom of cells, pour out the electrolyte into a glass bottle, and wash the cells out with clear water. Clean the terminals of any corrosion, and see that air vents are not clogged. Watch the accumulator and do not allow electrolyte to get below the proper level. If the storage battery is of the type in which the electrolyte is a jelly-like emulsion, see that it is kept moist on top by adding a little water to replace that lost by evaporation.

Ques. 142. How much electrical energy is required per candle power to operate an electric lamp?

Ans. A trifle over 4 volts; one 16 candle power lamp requires about one-twelfth of a horse power.

Ques. 143. What are the requirements of an electric motor for use in connection with a storage battery, for automobile propulsion?

Ans. It should be capable of withstanding an overload of over 100 per cent for at least thirty minutes at a time, without unduly heating.

Ques. 144. How many types of electric motors are in general use?

Ans. Three, viz., shunt-wound, series-wound, and compound wound.

Ques. 145. Which type of motor is usually in use on electric automobiles?

Ans. The series-wound, as it gives the most satisfactory results.

Ques. 146. Describe in brief the winding of a series motor.

Ans. The field magnets are wound with a few turns of very large wire. One end of this is connected to one of the commutator brushes, while the other end of the wire, and the other brush terminal connect with the battery, or other source of current.

Ques. 147. Describe the winding of a shunt motor?

Ans. The field magnets are wound with a great many turns of very small wire, the ends of which connect directly with the terminals of the commutator brushes.

Ques. 148. How are compound motors wound?

Ans. They are double wound; that is, with both shunt and series windings.

Ques. 149. Describe briefly the construction of the armature of an electric motor.

Ans. It is built up of a number of disks of sheet iron, separated by thin sheets of paper, or by the use of varnish between them to prevent eddy currents.

Ques. 150. What work does the commutator of an electric motor perform?

Ans. It receives the current from the battery, or other source, through the brushes, and transmits it to the armature coils.

Ques. 151. What are the essential features of an electric motor?

Ans. The brushes, the commutator, the arma-

ture, the field magnets, and pole pieces, the latter being an extension of the magnet core; and the magnet frame, usually of cast steel.

Ques. 152. What are some of the troubles connected with the operation of electric motors?

Ans. Open circuits, improper connections, and short circuits.

Ques. 153. Where may open circuits be looked for?

Ans. (1) At the battery terminals, which may be corroded, or loose; (2) in the controller, a connection may be loose, contact fingers not making good contact, or the removable plug may be out; (3) at the brushes, one may have fallen out, or springs too weak to insure good contact; (4) the reversing switch may be half way over, leaving batteries and motor on open circuit.

Ques. 154. If the ammeter indicates a large current, but motor refuses to start, what is the trouble?

Ans. Short circuit.

Ques. 155. How may it generally be located?

Ans. Lift one of the brushes, and if amperage drops, or disappears altogether, the short circuit is in one of the field coils; or a broken wire may be touching some portion of the metal of the car, or an exposed part of another wire.

Ques. 156. Mention three principal ways in which the speed of electric motors may be varied?

Ans. (1) By introducing variable resistances

in the motor and battery circuit; (2) by varying the voltage of the battery, using different combinations of the trays; (3) by connecting the field coils either all in series, in series parallel, or all in parallel.

Ques. 157. What constitutes one electrical horse power?

Ans. The current (C) in amperes multiplied by the electro-motive force (E) in volts, divided by 746; expressed as follows:

$$\text{E. H. P.} = \frac{\text{E} \times \text{C}}{746}$$

Ques. 158. How many watts are neecssary to deliver one mechanical, or brake horse power in practice?

Ans. 1,000 watts, expressed as one kilowatt.

Ques. 159. If the brake horse power of an electric motor be known, how may the efficiency be calculated?

Ans. By the following formula:

$$\text{e} = \frac{\text{B. H. P.} \times 746}{\text{E} \times \text{C}}$$

in which

e = Efficiency
B. H. P. = Brake horse power
E = Volts
C = Amperes.

Ques. 160. Define the term, Electro-Motive Force (E. M. F.).

Ans. It is the manifestation of energy in an electric current; as for instance, a current under a pressure of one volt will force one ampere through one ohm of resistance.

Ques. 161. What two causes are responsible for a smoky exhaust on an explosive motor?

Ans. (1) Over-lubrication; (2) too rich a mixture.

Ques. 162. What is the function of an exhaust muffler?

Ans. To deaden the noise of the escaping gases.

Ques. 163. What is liable to occur to an exhaust muffler if it is not cleaned regularly?

Ans. Carbon deposits on the interior, which will tend to increase the back pressure.

Ques. 164. What will be the result if the exhaust valve is allowed to close too early?

Ans. An excess of burned gas will remain in the cylinder, while if kept open too long some of the burned gas will re-enter the cylinder during the suction stroke.

Ques. 165. Upon what six conditions does the efficiency of the expansion in the cylinder of an explosive motor depend?

Ans. (1) Initial volume of the charge; (2) condition of the mixture; (3) compression pressure; (4) point of ignition; (5) piston speed; (6) losses due to radiation.

Ques. 166. How many, and what types of explosive motors are in general use?

Ans. Two, viz., two cycle and four cycle.

Ques. 167. What is meant by the term cycle?

Ans. The four stages through which the conditions in the cylinder must pass in order to develop one power stroke of the piston.

Ques. 168. Relative to the revolutions of the crank, how often does an explosive, or power stroke occur in a two cycle engine? A four cycle engine?

Ans. At every revolution, or every second stroke, in a two cycle engine, and every alternate revolution, or every fourth stroke of the piston, in a four cycle engine.

Ques. 169. How many compression chambers are required in a two cycle engine?

Ans. Two, for the reason that two cylinders, either side by side or tandem are required, and while the charge is being received in one, the previous charge in the other cylinder is being compressed preparatory to explosion.

Ques. 170. Define the stages of a single cylinder, or four cycle engine?

Ans. (1) Induction; during an out stroke of the piston the explosive mixture is drawn into the cylinder in proper proportions; (2) compression; on the return or in stroke the piston compresses this mixture into the clearance space; (3) explosion; the compressed mixture is ignited, causing a rapid rise in pressure, and subsequent expansion of products, causing an-

other out stroke of piston; (4) expulsion; the expanded gases are expelled by the returning piston.

Ques. 171. Define the stages of a double cylinder, or two cycle engine.

Ans. (1) Cylinder No. 1, charge compressed; piston ready to start on out stroke; cylinder No. 2, charged with mixture, piston ready to start on in stroke; (2) cylinder No. 1, charge exploded, piston completes power stroke; cylinder No. 2, piston completes return, or compression stroke.

F

Ques. 172. What is vulcanized fibre?

Ans. Paper pulp treated with sulphuric acid, washed and afterwards compressed into sheet, or rod form.

Ques. 173. Define the word friction.

Ans. Resistance to motion of two bodies in contact.

Ques. 174. What are some of the laws governing friction?

Ans. (1) Friction varies in proportion to pressure on surfaces; (2) it increases with roughness of surfaces; (3) friction of rest is greater than friction of motion; (4) the amount of friction is independent of the area of surfaces in contact when pressure and speed remain constant; (5) friction is greater between soft bodies, than between hard bodies.

Ques. 175. What are the conditions attend-

ing perfect lubrication of bearings and journals?

Ans. There is a continuous film of lubricant running around with the journal, and sliding over a similar film adhering to the bearing. The metallic surfaces do not touch each other.

Ques. 176. Under what conditions does the friction drive for power transmission show a high efficiency?

Ans. Conditions where the load is constant and uniform.

Ques. 177. Do these conditions exist with automobiles?

Ans. Not as a rule; but rather the contrary.

Ques. 178. Give the names, and average composition of the various fuels at present available for automobile use.

Ans. C = Carbon, O = Oxygen, H = Hydrogen.

Gasoline, average composition, C = 84, H = 16.

Benzine, average composition, C = 92, H = 8.

Alcohol, average composition, C = 32, H = 8, O = 35.

Tar Benzol, average composition, C = 92, H = 8.

Kerosene, average composition, C = 85, H = 15.

Motor spirit, consisting of Naphtha, Benzoline, Benzine, average composition, C = 85, H = 15.

Methyl Alcohol, consisting of Wood spirit,

Naphtha, average composition, C = 38, H = 12, O = 50.

Acetylene, Ethene, average composition, C = 92, H = 8.

Calorific value 25,000 B. t. u.

Ques. 179. Which type of explosive motor uses the larger quantity of fuel per H. P. developed?

Ans. The two-cycle engine.

Ques. 180. Give two principal reasons why the fuel consumption of the two-cycle engine is greatest.

Ans. First: Retention of a portion of the exhaust charge. Second: More or less loss of a portion of the fresh charge.

G

Ques. 181. What law governs the expansion of gases, with relation to temperature?

Ans. All gases expand equally 1/490th part of their volume for each degree Fahr. of their temperature.

Ques. 182. What is the main cause of the carbon deposits on the interior walls of the cylinders of gasoline motors?

Ans. Gasoline, which does not vaporize until it comes in contact with the hot cylinder walls.

Ques. 183. How may the vaporization of the gasoline be greatly accelerated before it reaches the interior of the cylinder?

Ans. By pre-heating the mixture on its way to the combustion chamber.

Ques. 184. Is it possible to manufacture a

homogeneous gas for use in a gasoline engine driving a motor car?

Ans. It may be accomplished by means of a gas producer carried on the car.

Ques. 185. Describe in brief the construction, and principles governing the action of a gas producer for automobiles.

Ans. It consists essentially of a copper tank, or container located in any convenient place, as under the driver's seat; which tank is filled with sheets of wood pulp superimposed. Each sheet is ¼-inch thick, and drilled full of holes ¼-inch in diameter. These sheets are separated from each other a slight distance. A space in the tank is occupied by a coil of pipe, around which the exhaust gases from the engine circulate, thus serving to heat the air which passes through the coil before coming in contact with the gasoline-saturated wood-pulp sheets.

Ques. 186. How is this mixture of homogeneous gas conveyed to the combustion chamber?

Ans. By means of a valve designed for the purpose, by which it may be diluted to meet the requirements of the engine according to road condition, atmospheric influences, etc.

Ques. 187. Is there any danger of an explosion of the gas within the tank?

Ans. There is not, for the reason that the gas is not sufficiently diluted with air to render it explosive.

Ques. 188. How are Gasoline, Benzine and other explosive fuels obtained?

Ans. They are distilled products of crude petroleum, the process of distillation being similar to that of generating steam from water.

Ques. 189. How many different kinds of gasoline explosions are there?

Ans. Two; first, the real explosion occurring in the cylinder of a gasoline motor when heat and pressure are suddenly produced by the combustion of the gasoline vapor; and, second, by placing an enclosed tank of gasoline over a fire, the heat will increase the pressure in the tank until it explodes, thus allowing the gasoline to instantly vaporize and mix with the air, and be ignited by the flame.

Ques. 190. Is water a good extinguisher of a gasoline fire?

Ans. It is not. On the contrary, it is worse than useless at such times.

Ques. 191. What, then, is the best method of extinguishing a gasoline fire?

Ans. Smother the fire with fine earth, sand or flour, thrown on top of the burning liquid. A dry powder which is very good for this purpose can be made of common salt 15 parts, sal-ammoniac 15 parts, bi-carbonate of soda 20 parts. Mix thoroughly and pass through a fine sieve.

Ques. 192. What should be done in case the gasoline takes fire at a small outlet, or leak in a gasoline tank?

Ans. Either blow, or pat the flame out.

Ques. 193. What is the first point to be considered in the design of a gasoline motor?

Ans. The proper number of cylinders.

Ques. 194. What single advantage attaches to the single cylinder motor?

Ans. Simplicity and fewness of parts.

Ques. 195. What advantages pertain to multi-cylinder explosive motors?

Ans. They develop more power with less weight, and they reduce vibrations and strains.

Ques. 196. What form of motor will give correct mechanical balance, and at the same time reduce vibration to a considerable extent?

Ans. The two-cylinder type, with cranks opposed, and cylinders in axial alignment.

Ques. 197. What is the next best construction so far as regular impulses, and uniform strain on the parts are concerned?

Ans. Three cylinders, parallel and having the cranks at an angle of 120 degrees to each other.

Ques. 198. What types of explosive motor combine the advantages of mechanical balance, and the reduction of vibration to a minimum?

Ans. The four or six-cylinder types.

Ques. 199. Mention a few other points to be considered in the selection of an explosive motor.

Ans. Arrangement of working parts so as to be readily accessible; automatic lubrication; the best and most simple method of operating

the valves; a reliable system of ignition; proper diameter, and weight of flywheel; the carbureter should be one requiring the least attention; reduction of weight and simplicity of construction in all parts.

Ques. 200. What is the best design for cylinders?

Ans. The cylinder with its combustion and valve chambers should be integral, having no joints to be closed by gaskets.

Ques. 201. What is a good average fuel consumption per horse power hour for a gasoline motor?

Ans. About one and two-tenths pints of gasoline.

Ques. 202. What will be the effect on fuel consumption if the cylinders are kept too cold?

Ans. The expansive force of the gases is reduced, and less power is developed by the motor.

Ques. 203. What is the object of cooling the cylinders?

Ans. To prevent the lubricating oil from burning up.

Ques. 204. What is a good rule for guidance in the matter of cooling motor cylinders?

Ans. The hotter the cylinder with effective lubrication, the more power will the motor develop.

Ques. 205. What rule should be observed when changing gear on the road?

Ans. The motor and the car should be mov

ing at nearly corresponding rates of speed before engaging the clutch.

Ques. 206. What rule should govern in climbing a hill?

Ans. The hill should be ascended as far as possible on high gear, and the change to lower gear be made as soon as the motor begins to labor hard.

Ques. 207. What method should be pursued in caring for the gear case and rear live axle casing?

Ans. They should be periodically emptied of oil, and accumulated metal grit, then thoroughly washed out with kerosene, and filled with fresh oil.

Ques. 208. What is implied in the term generator as used in connection with automobiles?

Ans. Any form of chemical, or mechanical device which is used to produce a current of electricity. The term also applies to the apparatus for generating acetylene gas for use in the lamps.

Ques. 209. Name the two forms of mechanisms used for ignition purposes?

Ans. First: the dynamo, which is self-exciting by means of coils of wire wound upon magnet limbs. Second: the magneto, having permanent magnets instead of coils, to induce the current in the armature.

Ques. 210. Which type is most generally used on automobiles?

Ans. The magneto, owing to simplicity of construction and low first cost.

Ques. 211. Describe the principles of the magneto.

Ans. It consists of two or more horseshoe magnets, the ends of which embrace the pole pieces between which rotates a shuttle armature wound with small insulated copper wire. Rotation of this armature disturbs the lines of magnetic force, which in turn sets up induced currents in the armature.

Ques. 212. What kind of electric current is thus produced?

Ans. Alternating; but it is converted into direct current by means of the commutator on the armature shaft.

Ques. 213. What is the function of the governor, as applied to explosive motors?

Ans. To control the speed, which may be done in three ways, as follows: throttling the supply of mixture; retarding ignition; preventing the exhaust valve from opening.

Ques. 214. May graphite be used as a lubricant for cylinders of explosive motors?

Ans. Only to a limited extent.

H

Ques. 215. What is meant by the term heat value of fuels?

Ans. The quantity of heat generated, or that may be generated by the complete combustion of the fuel.

Ques. 216. In what three ways may loss of heat result?

Ans. By convection; by conduction and by radiation.

Ques. 217. Which one of these three is the principal factor in heat loss in explosive motors?

Ans. Convection; owing to the violent motion of the ignited gas.

Ques. 218. Give the formula for ascertaining the horse power of an explosive motor.

Ans. First ascertain the number of power strokes per minute, then

$$\text{H. P.} = \frac{\text{PLAN}}{33000} \text{ in which}$$

H. P. = Horse power.
P = Mean effective pressure.
L = Length of stroke in feet.
A = Area of piston in sq. in.
N = Number of power strokes per minute.

Ques. 219. What is the best construction for hubs, and wheels of automobiles?

Ans. Ball and roller bearings, the hubs to be accurately machined from steel castings or die forgings.

I

Ques. 220. What two objects must be attained in order to gain the highest efficiency in operating an explosive motor?

Ans. First, a correct mixture of gasoline and air; and second, ignition of this mixture at the proper time.

Ques. 221. What form of ignition is the most practical for automobile service?

Ans. Electric, either by the primary method or the secondary method.

Ques. 222. How are these methods otherwise designated?

Ans. Low tension, and high tension.

Ques. 223. In common parlance what additional names are given to these two systems?

Ans. Low tension is termed, the make and break system, while high tension is called the jump spark system of ignition.

Ques. 224. What is the basic principle of induction in electrical action?

Ans. If a certain body has electrical or magnetic properties, it will call forth or produce similar properties in a neighboring body without direct contact.

Ques. 225. What is the nature of an electrical current that is produced by an induction coil?

Ans. It has a high electro motive force or voltage.

Ques. 226. When should the ignition always be retarded?

Ans. Just before the car is started.

Ques. 227. When should the ignition be advanced?

Ans. After the motor has attained a fair rate of speed.

Ques. 228. What is a good rule to remember regarding the handling of the ignition?

Ans. Greater motor speed requires an early ignition, but greater power calls for late, or retarded ignition.

Ques. 229. Describe some of the main troubles that occur with ignition systems?

Ans. Loose contact screws; vibrator improperly adjusted; faulty insulation of wiring; corroded battery terminals.

Ques. 230. What is the function of an Indicator?

Ans. By means of the indicator it is possible to obtain a card or diagram showing the action of the exploded gas upon the piston within the cylinder.

Ques. 231. Of what use are such diagrams?

Ans. They show whether the ignition occurs at the proper moment; also if release or exhaust is properly timed. The horse power developed by the motor may also be computed from an indicator diagram.

Ques. 231a. Define the meaning of inertia?

Ans. That property of a body by which it tends to continue in the state of rest, or motion in which it may be placed, until acted upon by some other force.

Ques. 231b. What are some of the preliminaries to be observed before starting a car?

Ans. Retard the spark as far as possible.

Open main gasoline valve at tank. Set throttle about one quarter open. Close switch and insert safety plug. Turn on oil feed in lubricating system. Open compression relief cocks if there are any. Prime carbureter by depressing the float or otherwise. Engage starting crank, and pull upwards smartly against the compression. The motor should then start; but if it does not, turn the crank until the next compression stroke, and again pull up smartly.

J

Ques. 232. What disadvantage attends water-jackets that are cast integral with the cylinders?

Ans. They are hard to clean when scale deposits accumulate in them.

Ques. 233. What other form of water-jacket is in use on small engines?

Ans. Jackets made of heavy sheet copper, which may be removed when they need cleaning.

Ques. 234. What should be the ratio of the water-jacket space around the cylinder, to the bore of the cylinder?

Ans. Not less that one eighth of the bore, and the space surrounding the head combustion chamber should be not less than one sixth of the cylinder bore.

Ques. 235. At what temperature should the jacket water be kept in order to attain the greatest degree of fuel economy?

Ans. Slightly below the boiling point (212°).

Ques. 236. What is the function of a universal joint?

Ans. A universal joint is used on some types of automobiles in order to allow the rear wheels, and axle to accommodate themselves to the inequalities of the road surface.

K

Ques. 237. Is kerosene available as a fuel for explosive motors?

Ans. It is to some extent.

Ques. 238. What is the specific gravity of kerosene?

Ans. It varies from 0.78 to 0.82, and it has a vapor flashing point at 120° to 125° F.

Ques. 239. What is the ignition point of kerosene?

Ans. 135° F; and it boils at 400° F.

Ques. 240. What volume of air is required for the combustion of one cubic foot of the vapor of kerosene?

Ans. 76 cubic feet of air to 1 cu. ft. of vapor.

Ques. 241. What is the heat value of one pound of kerosene?

Ans. 22,000 heat units.

Ques. 242. To what other uses may kerosene be put in connection with automobile operation?

Ans. It is a good cleansing agent. If injected into the motor cylinders and allowed to remain over night it will remove all deposits from the piston heads and cylinder walls.

Ques. 243. If a knocking or pounding is heard in the motor while running what does it indicate?

Ans. It is an indication that something is wrong with the machine.

Ques. 244. What kind of a sound is produced by premature ignition?

Ans. A deep, heavy pound.

Ques. 245. Mention some other causes of knocking and pounding?

Ans. Badly worn, or broken piston rings. Improper valve seating. A badly worn piston. Piston striking a projecting point in the combustion chamber. A loose wrist pin. A loose journal box cap, or lock nut. A broken spoke, or web in the fly-wheel. Fly-wheel loose on its shaft. Explosions during the exhaust, or the admission stroke, due to mis-fire. Ignition unduly advanced. Crank pin may not be at right angles to the connecting rod. The chain may be loose, and jump one of the sprocket teeth. Bearings at either end of connecting rod may be too loose.

Ques. 246. Where are knuckle joints used?

Ans. For connections in Steering Mechanism.

L

Ques. 247. What care should be given the acetylene lamps of an automobile?

Ans. Wires should be passed through the gas, and air aperatures at intervals in order to

keep them clear. The burners should be unscrewed occasionally and blown through, and the interior of the burner body be scraped clean of deposit. The lenses also should be kept brightly polished.

Ques. 248. What is a good solution for cleaning the lens Mirrors?

Ans. Equal parts of alcohol and water. Denatured alcohol is good for the purpose also.

Ques. 249. What should be done with the condenser when used in connection with the lighting system?

Ans. It should be located close to the lamps where it will catch all the condensation from the gas passing to the burners. It should be emptied at intervals, and all mud and other sediment cleaned out.

Ques. 250. Mention two defects that are liable to cause serious leakage of current?

Ans. Moisture in the mica insulation of the electrode; second, a bridge of carbon. Remedy: dry out insulation thoroughly, and clean lower end with a brush, and a little gasoline.

Ques. 251. What is a common cause of leakage of gasoline?

Ans. A very small hole in the float of the carbureter will cause it to flood.

Ques. 252. How may it be found?

Ans. By putting the float into boiling water, and watching for bubbles.

Ques. 253. How may leaky joints in gasoline, or water pipes be made tight temporarily?

Ans. By means of coarse linen, or canvas covered with a paste of litharge and glycerine, which in turn should be covered with adhesive tape.

Ques. 254. Mention a few peculiar places in which loose connections are liable to occur in the ignition system?

Ans. A platinum tip may get free from its carrying screw; a lead lug may break inside a storage battery cell; a copper wire may break inside its unbroken cover.

Ques. 255. What is absolutely essential to ensure easy running, and the reduction of friction to a minimum?

Ans. To see that all rubbing surfaces are supplied with a sufficient quantity of the kind of lubricating oil adapted to the conditions.

Ques. 256. What qualities should the oil used in motor cylinders possess?

Ans. It should have a flashing point of not less than 500° F, and a fire test of at least 600° F, together with a specific gravity of 25.8.

Ques. 257. Is graphite a good lubricant to use on automobiles?

Ans. It is mainly useful for plain bearings, and chains. It may also be used to advantage in the cylinders, if fed in small quantities, and uniformly.

Ques. 258. What is the chief danger occurring from the use of graphite in the cylinders?

Ans. Clogging the valves.

Ques. 259. Describe the operation of the splash system of lubrication?

Ans. The oil flows by gravity from a tank into the crank case which is air tight. From there it is splashed over the piston, and bearings.

Ques. 260. How often should this oil be renewed?

Ans. Every 100 miles run on small motors, and every 75 miles on large ones.

Ques. 261. Describe the force feed system of lubrication?

Ans. The oil is forced by a power driven oil pump through adjustable conduits to the various bearings, in such quantities as are needed.

Ques. 262. How does the weather affect the lubrication of a motor?

Ans. In cold weather the oil will thicken up, thus requiring a different adjustment of lubricators from that found suitable in warm weather.

Ques. 263. What precautions should be observed regarding oil pipes and conduits?

Ans. They should be kept thoroughly clear and free from deposits, in order that the oil may have an unobstructed passage.

Ques. 264. How are the differential, and change speed gears lubricated?

Ans. Gear boxes should be kept a little less than half full of oil, which should be changed at periodic intervals, and the gears cleaned.

Ques. 265. What attention should be given the wheels, in the way of lubrication?

Ans. They should be cleaned, and packed with grease once or twice a season.

Ques. 266. How are the latest designs lubricated?

Ans. Through the shaft or axle from the gear box.

Ques. 267. On shaft driven cars when the shaft runs through a sleeve, what is required?

Ans. The shaft requires to be daily lubricated.

M

Ques. 268. When it becomes necessary to remove a Magneto for repairs, what should be done?

Ans. See that all separable parts are properly marked, in order to facilitate re-assembling.

Ques. 269. What two important elements are to be considered in the design of a manifold?

Ans. First, length, which in a single cylinder motor should be four times the stroke; Second, Area, which should equal one-quarter the area of the piston.

Ques. 270. What other important point is to be considered in designing a manifold for a Multi-cylinder Motor?

Ans. The delivery of an equal weight of the mixture to each of the cylinders.

Ques. 271. Describe the action of a two port motor?

Ans. The first stroke of the piston produces a vacuum in the crank case, and the mixture rushes in through the check valve in motor case. The second stroke compresses the mixture, and when the inlet port is uncovered the mixture surges into the cylinder. The third stroke compresses the mixture entrapped in the cylinder, as both ports are then covered by the piston, and at the proper moment the mixture is ignited.

N

Ques. 272. Describe the construction of a needle valve?

Ans. It has a cone point, and a very fine thread on the stem.

Ques. 273. Describe the composition of a non-freezing solution for use in cooling radiators in cold weather?

Ans. To 15 lbs. chloride of calcium add 1 gallon of water. After the solution has become saturated add 2 to 3 gals. more of water; and a little lime to neutralize acidity. This solution freezes at 15° below zero, F.

Ques. 274. What will be the result if the water freezes in the water-jackets?

Ans. The jackets will burst unless they are made of copper.

Ques. 275. If the car is to be kept in a cold building when not in use, what should be done?

Ans. The water should be completely drawn off from the jackets.

Ques. 276. When the car is to left standing outside for an hour or so in cold weather, what should be done?

Ans. The motor and radiator may be covered with cloths or laprobes, thus retaining a portion of the heat.

Ques 277. How is gasoline affected by cold?

Ans. It does not vaporize so readily, and it is necessary to supply extra heat to the carbureter.

Ques. 278. Should fire ever be used directly for warming the carbureter, or other parts of the motor?

Ans. It should not. Hot water may be used provided none is allowed to get into the gasoline tank. Another method is to wring cloths out of hot water and apply them.

O

Ques. 279. Can oil be used as a cooling medium for explosive motors?

Ans. It can be used most effectively in the summer time, as it is then more easily circulated through the radiator.

Ques. 280. What kind of oil is used for this purpose?

Ans. Any common grade of machine oil.

Ques. 281. What is meant by an offset crank shaft?

Ans. A crank shaft, whose center is not ex-

actly in line with the centers of the cylinders, but is set slightly to one side.

Ques. 282. What is the object sought in this type of construction?

Ans. To have the connecting rod in the exact vertical position when maximum compression, ignition, and pressure occur.

Ques. 283. What advantage is gained thereby?

Ans. It is claimed that the force of the explosion will then come on the connecting rod endwise, and the piston will not be unduly pressed against the cylinder walls.

Ques. 284. In timing the valves of an offset crank shaft engine what additional factor must be taken into account?

Ans. The inclination of the axis of the connecting rod.

Ques. 285. Describe the action of the two cylinder opposed motor when in operation?

Ans. During one-half revolution of the crank shaft, one cylinder is compressing while the other is exhausting. During the next half revolution, the first cylinder will be firing, and the second will be drawing in its charge. During the next half turn, the first cylinder will be exhausting, and the second compressing, and during the next half turn, the first cylinder will draw its charge, while the second is firing, thus giving a power impulse in every revolution of the crank shaft.

Ques. 286. What is the main cause of overheating of cylinders of explosive motors?

Ans. Too much gasoline; too rich a mixture.

Ques. 287. Mention some other causes of overheating?

Ans. Insufficient cylinder lubrication. Wear of cams, tappets and valve stems. Deposit of a thin film of scale inside the circulating pipe, and radiator.

Ques. 288. What is the immediate effect of overheating?

Ans. To burn up the oil in the cylinders and crank case. The motor will begin to pound, and the cooling water to steam.

Ques. 289. What other serious result usually follows overheatings?

Ans. The motor will gradually slow down and finally stop, with the lubricating oil burnt up, and the pistons expanded and gripping the cylinders.

Ques. 290. What should be done when symptoms of overheating manifest themselves?

Ans. The motor should be stopped at once, and kerosene freely injected into the cylinders, while the engine is turned by hand to free the piston rings. Then allow the parts to cool.

Ques. 291. Should cold water be poured over the outside of the cylinder jackets to cool them?

Ans. No, because there is danger of cracking them by so doing.

Ques. 292. Give a simple method of testing for an overheated motor?

Ans. Let a few drops of water fall on the head of the cylinder. If it sizzles for a few moments the overheating is not bad, but if the water at once turns into steam the case is serious.

Ques. 293. What else may be done to cool the motor?

Ans. Detach the spark plugs, and turn the starting crank slowly. This will draw cold air into the cylinders and thus cool them inside.

P

Ques. 294. Describe in brief the various kinds of packing used on explosive motors?

Ans. Asbestos, made in the form of sheets, also in the form of woven cloth, and as string or rope. Rubber, in sheets either plain, or with alternate layers of canvas and rubber. Rubberbestos, and vulcabestos, made of rubber impregnated with rubber and afterwards vulcanized.

Ques. 295. Is paper a safe material to use for shims, of any sort?

Ans. It is not, as it is not reliable where pressures are high, and intermittent. If used at all it should be saturated with shellac, and squeezed in place before the shellac dries.

Ques. 296. Give a list of extra parts that should be carried on a car?

Ans. Bolts and nuts; chain links; dry battery cells; extra valves; inner tube; insulated

wire; packing; spark plugs; split pins; sticky tape; valve springs; washers.

Ques. 297. Is there any advantage gained by mixing picric acid with gasoline for use in explosive motors?

Ans. An increase of 20 per cent in motor efficiency is claimed for the picric-gasoline mixture.

Ques. 298. Describe the construction of a piston used in a gasoline engine?

Ans. It is of the single acting, or trunk type, made of cast iron, and turned to a good working fit in the cylinder. Near the upper end three or four grooves are cut entirely around its outer circumference; and in these grooves the packing rings are sprung.

Ques. 299. What is meant by piston displacement?

Ans. The volume swept out by the piston. It equals area of piston multiplied by length of stroke.

Ques. 300. What rule should govern the length of a piston when designing one?

Ans. For vertical cylinder, piston length should not be less than its diameter; for horizontal cylinder, piston length should be never less than one and one-third diameters.

Ques. 301. What law governs the velocity or speed of the piston in an explosive motor?

Ans. The velocity of the piston must be considerably less than the rate of combustion of

the explosive mixture, in order that the motor may develop power.

Ques. 302. What is the estimated maximum speed limit, or piston velocity?

Ans. Between 14 and 16 feet per second.

Ques. 303. What is the best material for the contact points of the vibrator of an induction coil?

Ans. Platinum.

Ques. 304. How may the polarity of electric terminals be ascertained?

Ans. Place the ends of the wires on opposite ends of a piece of moistened litmus paper. The negative pole will turn the paper red.

Ques. 305. Is porcelain a good material for insulation purposes?

Ans. It has higher insulative properties than lava, or mica, but it is more liable to break from too sudden change of temperature.

Ques. 306. What is the most obvious cause of pounding in an explosive motor?

Ans. The spark, or ignition too far advanced.

Ques. 307. Name some of the principal causes of preignition?

Ans. High compression; carbon or dirt on the piston head; sharp corners, and projections on inside of combustion chamber for soot or carbon to accumulate on.

Ques. 308. What is the best lubricant for a pump?

Ans. Grease, and it should be stiff enough to

prevent its being washed away by the water, and carried into the radiator.

Ques. 309. What law governs the action of a centrifugal pump?

Ans. The height of the lift depends upon the tangential force.

Ques. 310. What should be the minimum peripheral velocity of the pump wheel?

Ans. 500 feet per minute.

Ques. 311. What is a good indication that the pump is not properly working?

Ans. Steam issuing from the relief or outlet of the water circulating system.

Ques. 312. How may the pump be tested before starting?

Ans. Run the motor for a few minutes. If the temperature of the pipes is uniform, the circulation is all right.

R

Ques. 313. What rule should govern in the design of a radiator?

Ans. That the maximum surface should be exposed to the air, and the greatest freedom afforded for circulation of the cooling medium.

Ques. 314. What advantages attach to the circular tube for a radiator?

Ans. Minimum resistance offered to flow of liquid. Greatest strength for given weight. Minimum weight of tube for given cubic content of liquid.

Ques. 315. What is the disadvantage of the circular tube radiator?

Ans. Minimum radiating surface presented.

Ques. 316. What can be said in favor of the cellular type of radiators?

Ans. They are more easily cleaned of mud than any other type.

Ques. 317. What disadvantage attaches to the honey-comb radiator?

Ans. The large number of joints is likely to be a cause of leakage. They are also more difficult to repair on the road, than the tubular type with radiating pins, or discs.

Ques. 318. How many square feet of radiating surface per horse power is required in the thermo-siphon, or natural water circulation system of cooling?

Ans. About 5 sq. ft. per horse power developed.

Ques. 319. What is the most common cause of a radiator cap sticking?

Ans. Expansion of the threaded ring on which it screws. This is caused by extreme heat, and the cap will unscrew easily when cold.

Ques. 320. When, therefore, is the best time to fill a radiator?

Ans. Before beginning the run.

Ques. 321. In case it becomes necessary to unscrew a radiator cap when hot what should be done?

Ans. Cool the base of the ring under the cap but do not cool the cap itself.

Ques. 322. In regard to reversing of a car, what should the driver always remember?

Ans. The reverse gear of a sliding change gear should never be engaged until the car has been brought to a full stop.

Ques. 323. What is a rheostat?

Ans. A device for regulating the flow of current in a closed electrical circuit.

Ques. 324. How is this accomplished with a rheostat?

Ans. By introducing a series of graduated resistances into the circuit.

Ques. 325. What precautions should be observed regarding all rubber supplies?

Ans. They should be kept from contact with oil, kerosene, gasoline or grease.

Ques. 326. What is the maximum temperature to which vulcanized rubber should be exposed?

Ans. 130 degrees F.

Ques. 327. How may a good rubber cement be made. Give formula?

Ans. 1 lb. caoutchouc; 1 gal. coal tar naphtha; 20 lbs. shellac. Heat gently, and pour on metal plates to solidify. When needed melt.

Ques. 328. Give a formula for gutta-percha cement?

Ans. Two parts gutta-percha to one part

common pitch. Melt together, and stir well while melting, after which pour into cold water.

Ques. 329. What is included in the complete running gear of an automobile?

Ans. The frame, springs, wheels, motor, speed change gear, axles and all machinery except the body.

Ques. 000. What is the running gear usually called?

Ans. The chassis, a French word pronounced chassee.

S

Ques. 330. How may a scratched cylinder be temporarily repaired?

Ans. By filling the scratches with silver solder, and scraping flush with the bore. If the scratches are not too deep the cylinder can be rebored, and a new set of piston rings put in.

Ques. 331. What is the limit to increase of bore for a cylinder?

Ans. About one-sixteenth of an inch.

Ques. 332. What is one of the most useful tools to be carried on a car?

Ans. A good screw-driver.

Ques. 333. Define the secondary current of an ignition system?

Ans. The current that is induced in the fine wire of the induction coil by the sudden reversal of the magnetism of the core, which latter is

caused by the sudden interruption of the primary current.

Ques. 334. What are some of the causes of self-firing of an explosive motor?

Ans. An insufficient supply of lubricating oil, thereby causing the cylinders to overheat; the presence of soot in combustion chamber; water circulation working badly, causing the motor to overheat. Self-firing implies that the motor continues to run after the ignition current is switched off.

Ques. 335. What are the principal advantages connected with the shaft drive?

Ans. Absence of noise; the ease with which all parts may be housed in oil; protection from dust.

Ques. 336. Mention some of the disadvantages attached to the shaft drive?

Ans. It is difficult to repair; it is complicated; it has considerable end thrust.

Ques. 337. How may aluminum be cleaned?

Ans. By washing the dirty surface with hyposulphate of soda; then rinse with water, and dry.

Ques. 338. What is the best lubricant for the cupped leather washer of the tire pump piston?

Ans. Vaseline, as it clings to the leather.

Ques. 339. Upon what does the effieciency of the motor, to a large extent depend?

Ans. Proper regulation of the sparking device.

Ques. 340. What will result if the spark plugs are allowed to become dirty?

Ans. Mis-firing.

Ques. 341. What is the proper method of cleaning a spark plug?

Ans. Wash the points of the plug with a 50 per cent solution of muriatic acid applied with a tooth brush.

Ques. 342. What is the function of the speedometer?

Ans. To register the speed of the car, and the distance traveled.

Ques. 343. How is the speedometer driven?

Ans. By means of a large gear attached to the hub of the wheel, which meshes into a small gear at the end of a flexible revolving cable which in turn drives the instrument.

Ques. 344. Are short springs desirable in an automobile?

Ans. They are not, for the reason that they are more liable to break, than longer springs are.

Ques. 345. What important factor must be considered in the design of springs?

Ans. The elastic limit with regard to the dead, and maximum load to be carried by the car.

Ques. 346. What care can be given to springs tending to prolong their life?

Ans. The surfaces of the leaves may be lubricated at intervals, also the toggles and links.

Ques. 347. What should be done with the steering gear at frequent intervals?

Ans. It should be cleaned, and well oiled.

Ques. 348. What advantages are possessed by steam motors as compared with explosive motors?

Ans. Speed variations are obtained without the shifting of gears; they will start without cranking; they are noiseless, and are better for climbing hills.

Ques. 349. Name the principal parts of a steam motor for driving an automobile?

Ans. The boiler, the steam engine, the condenser, the water pump, gasoline pump and the pilot lamp.

Ques. 350. What type of boiler is available for automobile service?

Ans. The water tube type, only, and it should be of light construction and yet able to withstand very high pressures.

Ques. 351. What kind of fuel is generally used under the boiler?

Ans. Gasoline, which is passed under pressure through a vaporizer, and thence to the burner where it mixes with the air, and burns.

Ques. 352. How is the boiler supplied with water?

Ans. From a small tank or reservoir the water flows to the feed pump, which forces it, first through the feed water heater located in the exhaust pipe leading to the condenser,

where it absorbs considerable heat from the exhaust steam. From there into the boiler.

Ques. 353. What is the function of the pilot light in connection with a steam motor?

Ans. It is twofold; first for heating the vaporizer, and second for lighting the burner, as the fuel is generally supplied only intermittently to the burner, depending upon the steam pressure, which automatically regulates it.

Ques. 354. Wherein does the steam engine differ from the gasoline, or explosive engine used on automobiles?

Ans. A steam engine exerts power at each stroke of the piston. With the explosive engine, power is exerted only at every fourth stroke, or at best every alternate stroke.

Ques. 355. What type of steam engines are in use on automobiles?

Ans. Two cylinders, with cranks set at 90 degrees to each other. The engines have reversing valve gear, and may be either simple or compound.

Ques. 356. Explain what is meant by a simple engine?

Ans. A simple engine is one in which the steam having done its work in the cylinder is permitted to pass into the exhaust pipe, either to the atmosphere, or to a condenser.

Ques. 357. Explain the principles of the compound engine?

Ans. A compound engine consists of never less than two cylinders, and in many cases

more. In the two cylinder compound, such as are used on steam automobiles, one of the cylinders is called the high pressure, and the other the low pressure cylinder. Steam passes from the boiler first to the high pressure cylinder in which it does work, and from thence it passes to the low pressure cylinder which is always of larger bore than the high pressure. The steam now acts against the low pressure piston, doing work, and is then allowed to exhaust either into the atmosphere, or into a condenser.

Ques. 358. What types of valve gear are in general use on steam automobiles?

Ans. There are two—the Stephenson link motion, and the Joy valve gear.

Ques. 359. What are the duties of the chauffeur after the day's run is finished, and the car is run into the garage?

Ans. First, shut the battery switch, and remove the plug; close all oil cups and lubricators; shut off the gasoline if there is no float in the carbureter; if in winter and the car is to stand in a cold place, drain off the water from circulating system; wipe off motor, and see that it is ready for the next run; when cleaning the motor examine all bolts and nuts, and all other points needing adjustment; note the condition of journals, and bearings, and if any are unduly hot, ascertain the cause of the heating.

Ques. 360. Give a list of supplies that will be found very useful to carry on a long trip?

Ans. Asbestos, bolts and nuts, copper wire, emery cloth, emery powder, funnel, extra can of gasoline, gaskets, iron wire, machine screws, rope (small, strong), rubber pail, adhesive tape, washers.

Ques. 361. What is the advantage of a three point suspension for automobile frames?

Ans. Freedom of the power plant from stress, all parts remaining in perfect alignment.

T

Ques. 362. What is a tachometer?

Ans. An instrument for indicating the number of revolutions made by a shaft in a unit of time—usually one minute.

Ques. 363. How is the capacity in gallons of a cylindrical tank ascertained?

Ans. Multiply the area of the cross section in square inches by length of tank in inches, and divide by 231.

Ques. 364. What precautions should be observed regarding gasoline tanks?

Ans. Never put water into the tank. Always use a wire gauze-lined funnel. If the screwed cap for the inlet gets lost, get a new one; don't use a cork; small bits of the cork are liable to get into the carbureter.

Ques. 365. How should ignition batteries be tested?

Ans. Get a 4 or 6 volt one-ampere incandescent lamp, and after cutting the battery out of the charging circuit, put the lamp in the bat-

tery circuit for a few seconds only. If the battery is fully charged the lamp will give out a briiliant light.

Ques. 366. What is the difference between a single tube, and a double tube tire?

Ans. In a single tube tire the inner, or air tube is vulcanized to the outer tube. In a double tube they are separately attached to the rim of the wheel, and are not in contact, except when the inner tube is inflated.

Ques. 367. What advantage has the single, over the double tube tire in the matter of repairs?

Ans. A puncture through the tread of a single tube tire may be repaired by using rivet shaped rubber patches. With a double tube tire it is necessary to remove the casing from the rim of the wheel, in order to cement suitable patches upon the inner tube.

Ques. 368. What is implied in the term tonneau used in connection with automobiles?

Ans. The rear seats of a car.

Ques. 369. Describe in a general way a touring car?

Ans. The rear seats are non-removable; it has a carrying capacity of 5 to 6 persons; the motor ranging from 16 to 24 horse power; and the running radius is from 50 to 75 miles on one charge of gasoline and water.

Ques. 370. Mention a list of touring supplies to be carried in addition to those already enumerated?

Ans. Acetylene (carbide of calcium), cylinder oil, goggles, lap robe, lamp oil, lubricating oil, storm apron, tire bandage, waste, whiskey (for medical use only).

Ques. 371. What is the function of the torsion rod?

Ans. To prevent the twisting strain imposed by the shaft from reaching to, and affecting the frame at the rear end.

Ques. 372. What is meant by the traction of the driving wheels?

Ans. The push in pounds exerted by the rims of the wheels against the ground, multiplied by speed of car in miles per hour.

Ques. 373. What is the estimated efficiency of the various forms of power transmission?

Ans. Single chain with direct drive, 85 per cent; two chain drive from motor to speed change gear, thence to rear axle, 75 per cent; double chain with right angle drive, 70 per cent; longitudinal shaft drive, universal joints, and bevel differential, 65 per cent.

Ques. 374. Should a motor be slowed down by throttling the charge?

Ans. Not until the ignition has been retarded as far as possible.

Ques. 375. Is copper tubing serviceable for piping the gas to the lamp burners?

Ans. It is used to a large extent, but it is liable to erosion by the gas. Standard ⅛ in. gas pipe is better, and lasts longer.

U

Ques. 376. What is meant by the expression unit of heat?

Ans. A heat unit (B. t. u.) is the quantity of heat required to raise the temperature of one pound of water one degree, or from 39° to 40° F. The heat unit is used for calculating the quantity of heat contained in any form, and known weight of matter.

Ques. 377. How may the number of heat units in a given number of pounds of gasoline be ascertained?

Ans. By the amount of energy, or work (expressed in horse power) developed by the complete combustion, explosion, and expansion of the given weight of gasoline, assuming that none is lost.

Ques. 378. What is the mechanical equivalent of heat, or rather of one heat unit?

Ans. 778 foot pounds.

Ques. 379. What is a foot pound?

Ans. One pound weight raised one foot high.

Ques. 380. How is horse power calculated from the above mentioned data?

Ans. One H. P. equals 33,000 lbs. raised one foot high in one minute of time. One heat unit equals 778 foot lbs., or $778 \div 33000 =$ about 1/43 of a horse power.

V

Ques. 381 What care should be given the valves of an explosive motor?

Ans. They should be ground in at frequent intervals, using fine emery and oil, then finish with tripoli and water. Badly pitted valves should be replaced by new ones.

Ques. 382. What is liable to result from an exhaust valve sticking?

Ans. The motor may suddenly stop.

Ques. 383. What should be done in such a case?

Ans. The valve should be removed, and the stem be cleaned and scraped, and if it is warped it should be straightened. If the valve still leaks it should be ground to its seat.

Ques. 384. What is the function of the auxiliary air valve with the float feed carbureter?

Ans. To provide a larger air inlet for low speeds, than for high speeds.

Ques 385. How should the exhaust valve be timed?

Ans. So as to open slightly before the beginning of the inward stroke, and close at the end of the same stroke. The next inward stroke is the compression stroke when both valves should be closed.

Ques. 386. Where is the butterfly valve used?

Ans. In the admission pipe between the car-

bureter and the admission valve of the motor.

Ques. 387. What is its function?

Ans. To regulate, or throttle the supply of explosive mixture to the motor.

Ques. 388. What is the function of the swing-check valve?

Ans. It is attached to the air inlet opening of the carbureter to prevent leakage of the mixture, when suction operated admission valves are used.

Ques. 389. Where is the globe valve generally used?

Ans. In the pipe leading from gasoline tank to carbureter. By it the supply of gasoline may be entirely shut off.

Ques. 390. What objections are there to an excessive clearance between the valve lifters and valves?

Ans. (1) Vertical hammering, causing unnecessary noise; (2) sidewise pressure imposed on the valve lifters by the cams.

Ques. 391. About what clearance should be allowed for expansion of valve stems?

Ans. The thickness of a business card.

Ques. 392. What is meant by "lead" of valves?

Ans. Adjustment of the timing so that the valves open slightly before the completion of the particular part of the cycle they are intended to perform.

Ques. 393. What general rule governs the giving of "lead" to valves?

Ans. The higher the speed of the motor, the greater the necessity for lead.

Ques. 394. What objections attend the use of vaporizers in connection with carbureters?

Ans. They are wasteful of gasoline, and require frequent adjustment. They permit an excessive flow when the tank is full, and restrict it when the tank is nearly empty.

Ques. 395. Upon what does the saturation point for any given vapor depend?

Ans. Upon the temperature.

Ques. 396. What is meant by vapor tension?

Ans. The pressure exerted by the vapor in its saturated state.

W

Ques. 397. How many systems of water circulation are in use on automobiles for cooling the motor cylinders?

Ans. Two; the natural, or thermo-siphon system, and the forced water circulation.

Ques. 398. Explain the operation of the thermo-siphon system?

Ans. Cold water being heavier than hot water, the circulation is obtained by having a head of water in a tank located above the level of the cylinder water-jacket, and as the water in the jacket is heated, the cooler water from the tank flows in, forcing the heated water to take its place in the tank, an automatic circulation being thus kept up.

Ques. 399. How is forced circulation of the cooling element maintained?

Ans. By means of a rotary pump; the water passing from pump to jackets, thence to the radiators, on to the tank, and back through the pump again.

Ques. 400. What is the meaning of a watt-hour?

Ans. The voltage of the current multiplied by the rate of flow in amperes per hour gives the rate of energy expended in watt-hours.

Ques. 401. Describe the wipe-spark ignition system?

Ans. A form of primary sparking device used on some gasoline motor cars, but used principally on marine and stationary gasoline motors. The make and break is between a rocker arm on the side of the combustion chamber, and a spring plunger above the end of the arm, and in the center of the cylinder head.

Ques. 402. What will be the effect of the breakage of a wire in the ignition system of a single cylinder motor?

Ans. The instant stoppage of the motor.

Ques. 403. How would such an accident affect a multi-cylinder car, provided it was not the main circuit?

Ans. It would probably slow the car, with the result of explosions in the muffler.

Ques. 404. What causes wire-drawing of the mixture in carbureters?

Ans. A restricted intake.

Ques. 405. What are some of the bad effects of such wire drawing?

Ans. Excessive noises; reduction of power and waste of gasoline.

Ques. 406. Can wood-alcohol be used to any advantage in the cooling system of an explosive motor?

Ans. There is no particular advantage in using it, except to dispense with the use of water. The liability to freeze in cold weather is lessened however.

X

Ques. 407. Upon what principle is the action of the Xardell muffler based?

Ans. A vacuum is employed to create a suction upon the exhaust gases coming from the motor.

Z

Ques. 408. What is absolute zero?

Ans. A condition in which there is absolutely no vibration of the molecules, and consequently no heat. It has been calculated from experiments and observations to be a temperature of 461° below zero Fahr.

AUTOMOBILE DRIVING.

Automobile Driving. When on the open road, away from cities or towns, the following rules should be borne in mind. (1) Drive with moderate speed on the level, slow speed down hill, and wide open throttle for hill climbing, or getting up speed only. (2) The condition of the road should be noticed, the presence of mud or dust thereon furnishing sufficient reason for slowing down somewhat for the sake of other road users. (3) The ordinary rules of the road regarding the negotiation of turns, and crossings, also the overtaking or passing of other vehicles should be adhered to, even though a lower rate of speed is involved thereby. (4) A sharp lookout should always be kept for traffic of all kinds, as well as on approaching schools, churches, or public buildings, and also for road signs indicating danger, caution, etc. (5) When on the road the autoist should show courtesy to other road users. Courtesy in autoists is much appreciated, and goes a long way toward removing the prejudice which exists in many places against automobiles.

GEAR—CHANGING. In changing gears the autoist should endeavor to have the motor and car moving at nearly corresponding rates of speed before the clutch is engaged. With the planetary type of gear, changing is simple, and drivers usually guess at the proper period at which to make the change, any mistake in estimating the rates of the car and motor being of little consequence, as the bands will slip instead of transmitting the shock to the gear. A similar action occurs in the case of individual clutch or friction gears, but with the sliding type severe strains and shocks have to be taken up by the clutch, and are usually transmitted in part to the gear if the clutch is not slipped. What applies to the sliding type in general applies to the other types as well.

In changing from a lower to a higher gear it will be necessary to speed up the motor by means of the throttle or accelerator in order to store enough energy in the flywheel to furnish the work needed to accelerate the car to its new speed. As the speed of the car increases the higher gear should be engaged, the autoist not being in too great a hurry to make the change. The movement of the change gear lever should be made quickly in order that the car does not lose way. When changing from a higher to a lower gear the change should be made as quickly as possible before the car has time to slow down. When climbing a steep hill it should be ascended as far as possible on the

high gear by proper use of the throttle and spark, and the change down to the lower gear made as soon as the motor begins to labor or is in danger of stopping. The presence of an unusual number of passengers in the car will affect its ability to negotiate grades which ordinarily are taken on the high gear, and the autoist should remember this and not attempt to force the car to travel on that gear with the increased load, but resort to a lower gear.

Reversing—Backing Up. Among other things connected with driving which is apt to be neglected, is reversing, or driving a car backward. Usually a car is never reversed for more than a few yards at a time and the maneuvering involved requires no great skill. Steering a car when running backwards is diametrically opposite to that when running forward. A turn of the wheel to the left steers the car in the opposite direction to the right, and vice versa. The usual mistake made in reversing is in turning the steering wheel too far, and describing zigzags in the road as a result. The autoist should remember that the reverse gear of a sliding change gear should never be engaged until the car has been brought to a full stop.

Brakes, Proper Use of. Next to the motive power in importance come the brakes. There are a number of points regarding brakes that every autoist should know and remember. First and most important is the fact that brakes vary in their effectiveness, and that freedom from dis-

aster depends upon the brakes being kept in good condition and properly adjusted. Second, while a brake may be perfectly satisfactory for slowing down, it by no means follows that it will bring a car to a stop as it should, nor hold the car from going backward. Third, brakes should be tested frequently with the car in motion, the pedal or hand lever being applied until the car slows down, or stops. The distance covered in making this test should be noted, and a greater distance allowed in making stops on the road.

In applying brakes, the application should be gradual, reducing the speed of the car as quickly as possible without locking the wheels. As long as the tires retain their grip on the road, the powerful retarding action of the brake continues, but when the wheels are locked the brakes have little or no effect, and the car will either slide along, or skid, in either case being beyond the control of the driver. Should the wheels become locked while descending a hill, the brakes should be released until the wheels are again revolving, and then reapplied gradually, until they act satisfactorily.

Brakes should be examined at regular intervals in order to ascertain if the lining is in good condition. If worn, the old lining should be replaced with new. If the brakes are of the internal-expanding type, the shoes may have become worn, in which case they should be renewed. Toggle joints and adjusting nuts

should be inspected, and any looseness taken up. Brakes should be adjusted on the road, as any improper adjustment of the equalizer bar will have a strong tendency to make the car skid. Both brakes should be adjusted alike, that the braking force applied by the equalizer may be transmitted to the wheels equally.

SIDE SLIP, OR SKIDDING. If the rate of rotation of a wheel is greater than the rate of advance over the road, the wheel loses adhesion and thereafter it is just as easy for it to move in one direction as in another.

The wheel can now slip sideways as easily as it can slip forwards, particularly when it has the rounded section slightly flattened, which is the case with pneumatic tires. When traveling straight ahead, and with the motor out of gear, skidding does not usually occur. A slight turn given to the steering wheel checks the speed and introduces a side pressure on both front and rear wheels, due to the machine tending to continue its path in a straight line. Generally this side pressure will not cause skidding. If, however, the motor be suddenly thrown in gear, or the brakes suddenly applied, or, what amounts to the same, a large turn is given the steering wheel, the wheels find themselves either rotating more than in proportion to their advance, or advancing more than in proportion to their rotation. This immediately causes a loss of adhesion, which, once established, causes the car to skid or side-slip.

SPARK—REGULATION OF. Upon the proper use of the sparking device depends the economy of the motor, and in many cases the safety of the driver. On some cars the sparking point on the magneto is fixed, and the autoist controls the car by the throttle only. There are a number of cars in use which employ the battery in connection with separate coils or a single spark system, or a magneto on which the spark can be regulated by the driver. When starting, the spark should be retarded in the case of battery ignition, to prevent backfiring, and slightly advanced to a certain point, depending on the motor and magneto, in the case of magneto ignition. When it is desired to slow the motor down below the point obtained by throttling only, the spark is likewise retarded. In ordinary running, a position of the spark lever can be found which will give fair average results through a considerable range of speed without changing its position, and this position varies with each motor, and can be found by experience. When a higher rate of speed is desired, the throttle is opened and the spark advanced gradually. If a grade is to be negotiated it should be "rushed" if possible, the throttle being opened full and the spark well advanced until the motor begins to slow down and "knock," when the spark should be retarded to correct this. The autoist should always keep the spark as far advanced as possible, without causing the motor to knock.

WHEN TO RETARD THE IGNITION. Always re-retard the ignition before starting the motor, and take great care that the ignition is retarded and not by mistake advanced. Some cars are fitted with a device which prevents the starting crank being turned unless the spark is retarded. If it is not clear as to which way to move the ignition lever to retard the ignition, move the commutator in the same direction as the camshaft rotates.

As soon as the motor slows a little when going uphill, retarding the spark enables more power to be obtained from the motor at the slow speed, that is to say, if the spark is not retarded the motor will go slower than if it is retarded. Do not retard the lever to the utmost under these conditions; on the contrary, retard the lever to such a point that the knocking (due to the wrong position) ceases.

Retarding the spark causes the maximum pressure of the explosion to occur at the best part of the stroke, or, rather, the mean pressure of the explosion stroke will be lower if the best point of ignition by retarding is not found. This is a matter of some skill and practice.

To slow the motor, cut off as much mixture as the throttle allows, then slow the motor still further by retarding the spark, but on no account retard the spark when the throttle is full open (for the purpose of slowing the motor), as the motor will merely discharge a quantity of flame at a white heat over the stem of the

exhaust valve, burning it, softening it, and making it scale.

WHEN TO ADVANCE THE IGNITION. With too early ignition the pressure upon the piston becomes excessive and without any adequate return of useful work or energy. If the ignition be retarded too much, the maximum explosive pressure occurs too late during the working or power stroke of the piston, and the combustion of the gases is not complete when the exhaust-valve opens. Greater motor speed requires an early ignition of the charge, but greater power calls for late or retarded ignition.

The reason for advancing the spark when fast running is required, is that the explosion or ignition of the charge is not instantaneous as may be supposed, but requires a brief interval of time for its completion.

It may be well to explain without entering into theoretical details, that when a motor is running at normal speed, the ignition-device is so set that ignition takes place before the piston reaches the end of its stroke. The later the ignition takes place the slower the speed of the motor and consequently the less power it will develop. If, however, in starting the motor the ignition-device were set to operate before the piston reached the end of its stroke, backfiring would occur, resulting in a reversal of the operation of the motor and possibly in injury to the operator.

CAR INSPECTION. Most autoists are content to make all their inspection of the car and its mechanism from above, and rarely give more than a casual glance below the frame except when trouble occurs. On cars fitted with pressure-feed on the gasoline, the piping should be frequently inspected, on account of the danger from fuel leakage. Such inspections should be made when the motor is stopped, and the pressure still turned on. The tank should be gone over for leaks arising through the opening of its seams from vibration, or the loosening of the union connecting the fuel lead with the tank. The lead and its connection to the carbureter should also be examined for leaks and abrasions due to rubbing against other parts of the mechanism. If any such are found they should be immediately repaired. Twine, tire tape, or rubber bands will act satisfactorily as fenders to prevent further mischief. Unions which cannot be made tight by screwing up should be taken apart and the male connections coated with soap or red lead, which will render them tight for a considerable time.

After going over the fuel system, the brake rods and steering connections should be examined for loose joints and broken oil and grease cups. Grease boots on the drive-shaft joints should be seen to be sound, and filled with grease. A cleaning out of the dirt from the interior of the mud-pan will often reveal lost cotter pins or nuts, and tend to a more agreeable handling of the draincocks, carbureter and fil-

ter. This time will be well spent when the chances of fire or accidents arising from faulty steering or brake connections are taken into account.

DONT'S. In the first place don't forget to ascertain the fact that the ignition mechanism is retarded before cranking the motor. Many a sprained wrist and a few cases of broken heads or arms have been caused by the neglect of this simple precaution. It is a good plan to have the ignition-control spring so actuated that in its normal position it is always retarded.

Don't use the electric starting motor to propel the car. It ruins the battery.

Don't use a match or a small torch to inspect the carburetor. It sometimes leads to unexpected results.

Don't forget to fill the gasoline tank before starting.

Don't smoke while filling the gasoline tank.

Don't take out all the spark plugs when there is nothing the matter, except that there is no gasoline in the tank.

Don't forget to always have an extra spark plug on the car.

Don't allow the motor to race or run fast when out of gear. If the car is to be stopped for a few minutes, without stopping the motor, retard the ignition and also throttle the charge, so that the motor will run as slowly as possible.

Don't fill the gasoline tank too full, leave an

air space at the top or the gasoline will not flow readily.

Don't forget to put distilled water in the battery every ten to fifteen days.

Automobile Tools. In Fig. 1 three types of valve lifters are shown. B and C are of the same principle, and quite efficient in almost any case; but A, when properly operated, and on its respective motor, is more quickly applied,

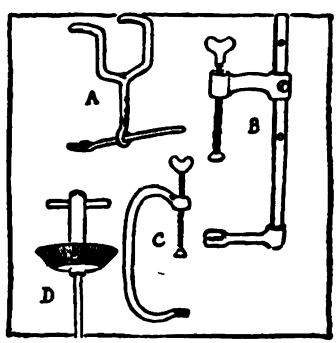

Fig. 1

and consequently a time saver. D is a valve-seating tool, supplied as special equipment by one of the large motor car manufacturers.

In Fig. 2 are shown a couple of spanner wrenches and one or two other tools that are quite uncommon but quite necessary in the work to which they are adapted. A is made from a piece of steel tubing and used on packing glands—the tube to slip over the shaft—and the small lugs at the end engage corresponding

recesses in a packing nut. B is representative of a valve-grinder, designed especially for the valves in certain motors. The spanner C is required to conveniently remove certain types of cylinder plugs; while D, which approaches the conventional, is used in adjusting bearings of a particular type.

There is probably a greater variety of wheel and gear pullers now in service than of any

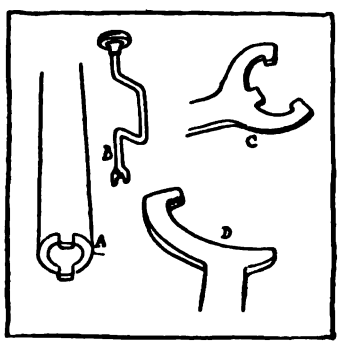

Fig. 2

other special tool. In Fig. 3 A looks very much like the standard adjustable wheel and gear puller for sale in all supply houses; and it practically is the same except that the hooks are larger and twisted in opposite directions and at right angles to the beam. It is found useful in removing road and flywheels and the like. B is a non-adjustable tool made especially for removing flywheels. C and P are road wheel pullers, and are included in the regular equip-

ment of tools supplied with the cars of two prominent manufacturers. C is part of the Rambler tool equipment and is used in connection with their spare wheel; and P represents the type of wheel puller supplied by the Pierce-Arrow. E is a gear-puller designed to remove the half-time-gears of an Oldsmobile, the two

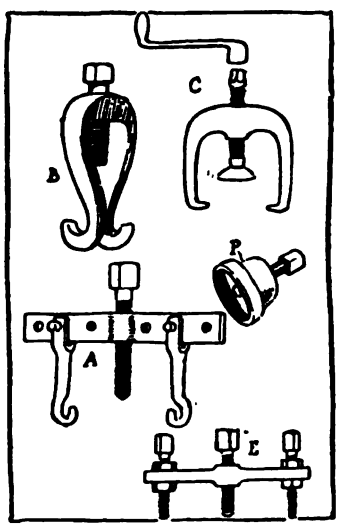

Fig. 8

side-screws being intended to fit into threaded holes in the web of the gears.

When the Jack is Missing. Should the jack be missing or broken, an efficient substitute can be rigged from a large stone or a number of bricks piled one on another until the height is sufficient to lift the wheel from the ground.

Having gotten the stone or piled the bricks one of the floor-boards can be utilized as an inclined plane and the car backed up until the axle rests on the top of the pile. When the work has been performed, the axle will have to be pushed off the pile, but as the drop is inconsiderable no harm can come to the tire. Where stake-and-

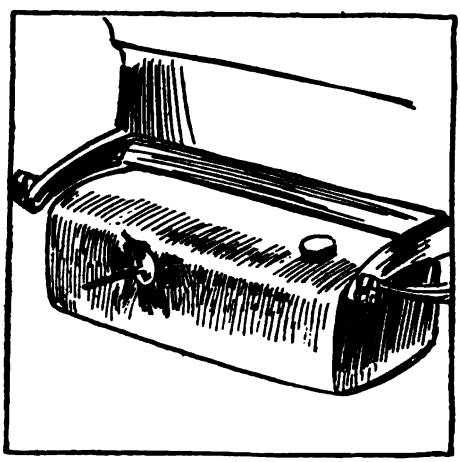

Fig. 4
Removing Dent in Gasoline Tank

rider fences abound, one of the rider timbers can be utilized as a lever, with a stone as a fulcrum to raise the axle, supporting the latter with another stone during the repair, and gently easing down the axle when ready to proceed.

REMOVING DENTS. An easy method of removing dents consists of soldering a piece of wire to the bottom of the dent, then pulling the de-

pressed portion out to its proper position. When the dent happens to be in an oil, or gasoline tank, or a radiator, an old valve can be most effectively used in place of the wire, as shown in Fig. 4 The top surface of the valve is filed smooth and bright, then cleaned with soldering acid and tinned with solder. A flat surface of the same area, and as near the bottom of the dent as possible, is treated in the same manner, and the valve sweated on. This sweating on is done by placing the prepared portion of the valve against the tinned surface of the dent, and then applying heat with a torch till a fusion of the solder takes place. The heat should then be removed and the solder allowed to set. When cool, it will be found that with the valve stem as a handle and lever, and probably a few light taps with a hammer around the edge of the dent, the deformed part can be most easily straightened out.

TOOLS NECESSARY. The following tools should be in the car when on the road:

Monkey wrench, 9 inch.
Machinist's screwdriver.
Ball pene hammer, one pound.
Combination pliers, 8 inch.
Set of double end, or "S" wrenches.
Flat file, mill cut.
Three cornered file.
Round file, six inch.
Center punch.
Prick punch.

Drift punch, flat ended.
Offset, or "bent-end" screwdriver.
Cold chisel, three-quarter inch.
Spark plug wrench.
Small wire cutting pliers.
Emery cloth.
Cotter pin puller.
Wire brush for spark plugs.

PART II

REPAIR MANUAL

INTRODUCTION

Along with the tremendous increase in the number of cars on American streets and roads there has come a similar increase in the number of owners who prefer to take care of their own cars. Not only is there a monetary consideration which leads owners to be their own garagemen and repairmen for the sake of economy, but the truly ardent motorists take as much pride and pleasure in caring for their inanimate mounts as does the horseman his four-footed companion.

The great advance in the reliability of motor cars as a whole and the effort that is made by designers to produce cars that need little beyond the occasional adjustment and ordinary care to keep them in good condition has made it possible for the owner to be free almost entirely from the professional repairman. Owners in general are desirous of knowing their cars and repairing them when necessary and diagnosing their ailments before they become serious, just as a mother does her child.

Experience has shown that it is in the minor adjustments of the different parts of the car with which the owner-repairman has the most difficulty. When the causes of improper working of the vehicle

are ascertained, usually it is a simple matter to remedy them with the simple tools at hand in any owner's garage.

In the following pages it is intended to outline the more common troubles of the gasoline motor car, showing their causes, how the symptoms may be recognized and how they can be remedied in the easiest way with the common tools in the motorist's repair kit. Among the commonest causes of trouble are misadjustments of such parts as the carbureter, magneto and so on. The methods of adjustment and repair of the more widely used types are explained and illustrated.

Likewise, the more ordinary difficulties which obtain in the motor itself are dealt with. The methods of determining valve trouble, valve adjustment and the operation of valve grinding are taken up. The last chapter will be found particularly valuable to the man who wishes to keep his tire bills low, showing the various tire ailments, their causes and their cure.

I

MOTOR KNOCKS.

No piece of machinery with moving parts is absolutely free from noise, but the following treats the common and unnecessary noises or knocks. These may be classed as follows:

1. Early Ignition Knocks:
   a. Due to spark being advanced too far.
   b. Due to carbon being present on the cylinder head.
   c. Due to an excess of fuel fed to the cylinder.
2. Loose Part Knocks:
   a. Loose connecting rod.
   b. Loose wrist pin.
   c. Loose piston.
   d. Loose flywheel.
   e. Worn cylinder.
3. Play or backlash between timing gears being too great.
4. Slaps.
   a. Piston ring slap.
   b. Valve slap.
5. Push rod knocks.

The Ignition Knock.—This knock when present in a motor gives a sharp metallic sound similar to that heard when two hammer heads are lightly hit together. It would be best for the reader to hear this sound for himself by advancing the spark

as far as possible when the motor is pulling up a grade.

The Carbon Knock.—Since a carbon knock is due to the presence of carbon on the cylinder head and piston top and since the knock is identical with the spark knock, in sound, it will be best to tell the characteristics of this knock by the characteristics of carbon being present. These are as follows:

First. The motor will not pull as well as it should, that is, it will labor on grades. This is best expressed by saying that a loss of power is evident.

Second. The motor will overheat after running perhaps only an hour. The cylinder underneath the water jacket will be intensely hot. In the summer, of course, the motor becomes hot more quickly.

Third. The motor will misfire.

Fourth. After the switch has been turned off the motor will continue to run, perhaps a dozen revolutions.

Fifth. A knock due to carbon is only heard while explosions are taking place in a cylinder.

The Fuel Knock.—This class of early ignition knock sounds just like a spark knock, but is accompanied by misfiring, backfiring or choking, as it is called.

The Loose Part Knock.—Knocking due to a loose part will sound much louder than any of the above mentioned knocks and is not as sharp or metallic. Should a piece of gas pipe be hit back and forth against two spokes of a wooden wheel, the sound heard will be almost the same as that given by a loose part.

There will be noticeably more vibration of the

car when some part of the motor is loose and cranking is not as difficult. A loose flywheel makes clutch releasing difficult.

Timing Gear Knock.—When the timing gears have too much play or backlash between them a rattling sound is heard, very much like the rattle of the chains of a big motor truck. When the motor stops the gears are heard to gently hit each other, or slam. It is often referred to as a gear "slam." Noisy timing gears may usually be heard above any other motor noises.

Slaps.—The ring slap gives a sound characteristic of itself and can very easily be distinguished from other motor noises. A piece of ordinary uninsulated telephone wire being hit against the channel of the car frame sounds very much like it. Although the slap may be heard slightly when no explosions are taking place in a cylinder, still the slapping is very much louder when the cylinder is firing.

A reproduction of the sound of a valve slap may be had by tapping the face of a twenty-five cent piece on a solid, flat piece of metal.

Push Rod Knock.—This clicking sound is not much different except in volume from that heard when the rod hits the valve stem due to an excess of play between the tappet and stem.

CAUSES.

The Spark Knock.—Should the motor be running slowly up a grade or under a heavy load and the spark advanced too far (occurring too early), the tendency on the part of the expanding gases to

push the piston downward and the desire for the piston to go up due to momentum will force the piston against the cylinder wall. This rocking against the wall continues until the piston has reached the bottom of its stroke. Although the space between the cylinder wall and piston is exceedingly small (possibly .004 inch), nevertheless this rocking will occur.

The Carbon Knock.—This, of course, is due to an excess of carbon on the cylinder head and piston. The carbon deposit is not smooth but particles protrude here and there. These particles become incandescent or red hot and cause the incoming gas to explode before it should. This early ignition of the gas causes the piston to rock in the cylinder as in the advanced spark knock.

Since carbon is a better retainer of heat than the metal of the cylinders, it is evident that the carbon will store up a lot of heat that would ordinarily be transmitted to the jacket water.

An improperly seating valve due to carbon on the seat will cause apparent misfiring. However, the valve not seating properly, allows part of the gas to escape in the compression stroke with the result that the explosion is very weak, giving the impression of misfiring, but when the cylinders are tested it will be found they are firing regularly. There are so many things that may cause misfiring that it is not safe to say that it is caused by carbon alone.

Overheating may be attributed to a number of things other than carbon. This will be discussed later.

Fuel Knock.—Too much gas being fed suddenly

to the cylinders causes this condition. The excess of gas not being able to get out on the exhaust stroke remains behind in a burning condition. This causes the early ignition and hence the knock. Gas merely burning does not expand as does the exploded gas and hence lingers in the cylinders with the exhaust valve open. When the motor is pulling slowly, open the throttle as wide as possible and very quickly. The knocking will immediately be heard.

A Loose Part Knock.—Rarely is this caused by the parts being poorly fitted at the factory, but nevertheless this may happen. Usually, however, insufficient oiling is looked to for the cause of a loose part. Running the motor with too little water will cause the parts to become hot, wear rapidly and then, of course, knock.

If the oil in the reservoir is allowed to remain there for too long a time without change it may become saturated with particles of carbon and these make their way to all the rubbing surfaces and scratch them, with the result that that part becomes loose. This is true especially of composition metal bearings. Clutch thrust will sometimes cause a loose flywheel.

Timing Gear Knocks.—This is more often due to insufficient oiling than to poor case hardening or to being poorly fitted. All factories allow a certain amount of backlash between all gears, but that means that the gears must be oiled well when running.

A defective gear tooth will break off and naturally cause a knock.

Sometimes, while the oil in the gear case is being

brought to level a little piece of dirt may drop into the case. This will also cause the gears to become noisy later.

Slaps.—Although the valves should fit the seat perfectly at all angles still this is not always the case.

The ring slap may be caused in either of two ways, as follows: Should there be any play whatever (up or down play) between the ring and its groove, the latter will slap against the groove walls. Second, should the rings' ends touch each other the ring will be forced against the cylinder wall, emitting the same sound.

Push Rod Knock.—This is largely due to the rod being poorly fitted to the guide, but insufficient oiling will increase the looseness rapidly. The loose rod being thrown against its guide by the cam causes the knocking to be heard.

DETERMINING THE KNOCK.

It is not customary in all cases to depend entirely upon sound to determine just what is causing the motor to knock, and now since the characteristics and causes of motor knocks have been enumerated, it will not be difficult to locate the knock, by a process of elimination as follows:

Let us say that the motor is pulling and a knock is heard that cannot be distinguished by its sound. The spark should be retarded fully and should the knocking cease it naturally follows that the spark was advanced too far. The spark connections should be examined and all play taken up. Should the knocking continue with the spark lever re-

tarded, carbon symptoms should be looked for. The car should be run up a grade with the spark fully retarded, and if the motor labors greatly it may be that carbon is in the cylinders. Note if the motor is overheated, that is, if the water is steaming and the cylinders are too hot to be touched. However, these are not to be taken as final, unless it is seen that the cylinders are receiving the proper amount of oil and that the water in the radiator has not run too low, for these conditions also cause overheating. Look for water or oil leaks.

Since a carbon knock will not be heard unless explosions are taking place in a cylinder, it follows that the motor should be run on one cylinder at a time and the knock listened for in each cylinder. In the case of a motor with knife switches this is an easy matter. Simply open three switches at a time. If the knocking is heard while the cylinder is running idle it is not due to carbon. All the cylinders should be tested in this way.

When the motor has no knife switches each cylinder should be short-circuited with a hammer by placing the head of it against the top of the spark plug and touching the cylinder. In this case each cylinder is run idle, and hence, if the knocking disappears, there may be carbon present. If the knocking continues with the cylinder running idle, the knocking is not due to carbon, but to some loose part.

A look at the intake valves (seen by removing the cylinder plugs), will tell the extent of any carbonization. These valves are kept clean by the incoming gasoline vapor and should they be heavily carbonized (not merely sooty), it is certain that

more carbon exists on the cylinder head and piston. The fan should be operating properly. The fan belt should not slip on the pulley.

Of course, misfiring may be the result of a number of things. For example, a rich mixture, a weak mixture, a sooty spark plug, a poor adjustment of the make and break points of the magneto (or battery coil), or a loose wire. So it follows that these various things should be looked after before it is said that the carbon is causing the misfiring.

We draw from the above then, that should the oiling system, water system and ignition system all be in proper working order and the motor shows a loss of power, overheats and perhaps misfires and above all, knocks, there is surely a carbon deposit on the cylinder head. The motor running after the spark switch has been turned off is added proof.

Of course the fuel or gas knock is usually the result of poor handling of the motor, but nevertheless all the throttle lever connections should be carefully inspected, for play. Sometimes when the throttle lever is closed the butterfly is open. Then when the operator is giving what he thinks a little gas, in reality he is feeding too much.

Those motors operating with air pressure feed often have the gasoline under too great pressure. If such is the case, bring the pressure back to its usual gauge pressure.

A loose part will always knock whether explosions are taking place in a cylinder or not. However, for perhaps twenty minutes after very heavy oil has been put into the reservoir the sound may

not be heard. The oil takes up some of the play, until it becomes thinned by the heat.

It is almost impossible to distinguish between a loose rod and a loose piston or a worn cylinder and loose wrist pin simply by the knock, for it depends entirely upon how worn these different parts may be. For example, a worn cylinder and a loose piston produce the same sound. But a rod worn but two thousandths of an inch may sound like a wrist pin that is worn perhaps five thousandths.

Since determining exactly what part is loose requires the removal of the cylinders (except in the case of a loose flywheel, noisy push rod, or valve and connecting rod lower end bearing), it is only necessary to find out whether any internal part is loose. In doing this, the throttle should be opened wide for a few seconds and then suddenly closed. The knock is more distinctly heard when the motor is slowing down. Since a loose part knocking is aggravated by the explosions, it is well to listen to each cylinder separately or cut out a cylinder as the case may be (that is, with or without knife switches). Speed up the motor and then suddenly close the throttle while listening to the separate cylinders. In listening put the ear as close as possible to the cylinder, and should there be a loose part it will be very distinctly heard as soon as the speed of the motor is increased.

Since it does not take very much time to inspect the lower connecting rod bearings, this should be done immediately after it is ascertained that a loose part knock is present. To do this proceed as follows:

Drain the oil from the reservoir and then remove the crankcase cover, or hand-hole covers. One man should get underneath the car while the other operates the crank. The one underneath should place his forefinger and thumb on the sides of the bearing and feel for play in any direction, while the other turns the crank handle slowly. Should any rise and fall of the bearing from the crankshaft or side play be felt the bearing may be considered loose and will cause a knock.

In determining whether a knock is caused by a loose flywheel, the frame should be straddled and a firm grip taken on the flywheel. The latter should be pulled up and pushed down, and if any play whatever is felt, the knock surely will be heard. The flywheel should be pushed back and forth sideways (an iron bar used, if necessary), and the connections to the crankshaft inspected. Bolts and nuts usually hold the flywheel to the shaft and these should be very tightly drawn.

If the lower end of the rods are tight and the flywheel bearing is not worn, then the internal knock is due to a loose piston, worn cylinder or loose wrist pin, and to determine which it is, and the extent of the looseness, the cylinder must be removed.

After this is done the wrist pin should be inspected and should there be any up or down play whatever the pin is considered loose and will cause a knock.

Then the piston should be taken off and fitted into the cylinder. One should not be able to get a single thickness of newspaper between the piston and cylinder. This space should be so small that

the piston cannot be rocked even a trifle in the cylinder. Of course, it cannot be determined whether the piston is loose or the cylinder worn until both are measured and compared with the true dimensions.

Although noisy timing gears may be distinguished by their sound alone, should this not prove satisfactory the radiator and gear case cover must be removed in order to inspect the timing gears. The play or backlash between the gears is measured by spreading two gears that mesh with a screwdriver and the play measured. This play should not exceed .008 inch, or the thickness of a sheet of newspaper, doubled.

The valve slap is determined only by its sound, but one can tell which valve is slapping by compressing the spring while the motor is running, thus preventing the valve from moving. If the slap disappears while this is being done, you have the noisy valve.

The ring slap is best heard in a cylinder when that cylinder is running alone. The throttle should be opened wide and then suddenly closed, the slap being heard more distinctly in this way. When the motor has no knife switches, a hammer should short circuit the cylinder. Here the slap is loudest when the hammer is suddenly taken away.

It is not best to rely upon the sound entirely in determining a push rod knock, since the rod is removed easily. Should one be able to place the corner of a visiting card between the push rod and its guide the play is said to be in excess and will cause knocking.

If there is uncertainty as to which rod is knocking, remove all for inspection.

CURING THE KNOCKS.

The Spark Knock.—All the spark connections being tightened, it remains to follow this rule to avoid spark knocking: Advance the spark only with an increase in motor speed and retard with a decrease in speed.

The Carbon Knock.—In order to cure a carbon knock it is necessary to remove the troublesome carbon from the cylinders. This should first be tried without removing the cylinders.

When the car is in the garage for the night, pour about one-third tumberful of kerosene into the cylinders through the pet cocks or through the openings intended for the spark plugs. Allow this kerosene to remain in the cylinders all night. Do not put too much kerosene into the cylinders as any excess may run into the oil reservoir and make matters worse later, because kerosene is very rich in carbon and gives it up when burning. Furthermore kerosene has a cutting effect between piston and cylinder. Crank the motor twice after injecting kerosene.

When the kerosene is allowed to remain in the cylinders over night it tends to loosen the carbon. In the morning the motor should be run with throttle three-fourths open for about five minutes, thus permitting any loosened carbon to blow out. The cut out, if any, should be opened while the motor is speeding. Black smoke appears at the cut-out.

Should the kerosene not cure the knocking it

remains to scrape the carbon, and this, too, should be first tried without removing the cylinders.

For this operation, three varieties of scrapers are to be used: One for the top of the piston, one for the cavities around the valves, and another for the cylinder head. The degree of curvature of one of these should be as near as possible to the curvature of the cylinder head.

All the cylinder plugs should be removed, and as in the case of a Knox or any motor with detachable cylinder heads, these heads should be removed.

Too much scraping should not be done. That is, after the carbon has been scraped from a given space, do not keep scraping the metal. This is injurious. One can tell when the scraper is touching the metal, for that grinding which is felt when scraping carbon, disappears.

After the carbon has been scraped, blow out the cylinders with compressed air. If this is not at hand use a tire pump to generate a draught. The cylinder plugs should be replaced, first noting whether the plug gasket is in good condition. A little common stove blacking on the plug threads will prevent any compression leak and is much better than red lead. When the latter is used it is difficult to remove the plug when again necessary.

Should this method not prove successful in removing all the carbon, it will be necessary to remove the cylinders. This is the most efficient way of ridding the cylinders of carbon and therefore the knock. As the carbon deposit may be seen by looking into the cylinder and on the piston top, it is a simple matter to scrape only the carbon and not the metal surfaces too.

The three scrapers previously mentioned should be used, but should the carbon deposit be thick and very hard, a flat end cold chisel may be used, but very carefully. For chiseling the cylinder head a curved chisel should be used. When the greater part of the carbon has been removed with the chisel the remaining portion should be scraped.

The end of one scraper should be used for removing the carbon in the ring slots and on the rings.

In removing the rings a simple method is as follows: Take two pieces (each about four inches long), of an old saw blade. Force the ring ends out as far as you can and by slight bending place one of the pieces of blade under the ring. Slide this piece around until half way around the piston. The other piece of blade is easily slipped behind the ring right next to the first piece. The blades are then moved around until the ring is resting on the blades only and the ring is then slid off the piston, the blades being used as tracks.

It is customary, after the carbon has been scraped to grind the valves. But this operation will be taken up in another article.

The Fuel Knock.—All the carbureter connections should be carefully looked after for any play and this play taken up. The float should not leak. It should be seen that when the throttle on the steering post is moved, the connections to the carbureter move proportionately. Since this, like the spark knock is usually due to the poor operation of the motor it would be proper to say that the gas should be fed slowly. That is, do not open the throttle suddenly and as wide as possible

when the motor is running slowly. The speed should be increased gradually.

Loose Parts Knocks—The Connecting Rod.—Should the one inspecting the rod bearings from underneath (that is, the lower rod bearings), find any play whatever, in any direction, this play must be taken up. However, this can only be done by removing the connecting rod. Of course, the cylinder and piston must first be removed and by taking off one, two, three or four (as the case may be) nuts and bolts that hold the two parts of the rod together, the rod is slipped through the hole over which the cylinder rests. Any end play may be taken up in a makeshift way by slightly tapping the flange at the ends of the bearing, thereby spreading it, that is, by making it longer. Do not spread the bearing too much. Spread a little and then see if it fits the crankshaft without play. If not, spread a little more, and so on.

In order to remove any up and down play it is necessary to thin the shim that rests between the bearing halves. This shim usually is in two parts. The shim parts should be filed at the same time. Good filing is necessary as the shim should be perfectly level. The filing should be done with a flat mill file. The usual precaution must be noted and that is, do not file too much. File just a little and see if the bearing fits the crank-shaft without play. Of course, the bearing should first be placed on the rod.

There should be no play in any direction and still the rod must move freely. After the bearing is made to fit it should be oiled well.

The upper connecting rod bearing or the one

upon which the wrist pin rests usually is not adjustable; and should there be any wear, the bearing should be replaced with a new one. However, in the case of excess end play the bearing may be spread as with the lower bearing. The bearing should be well cleaned before being replaced.

In placing the rod back in position the nuts at the lower end should be properly tightened. This will insure perfect fitting between both halves of the rod. The nuts should not be drawn too tightly for this may spring the bolt; that is, stretch the bolt. When there is more than one of the nuts they should be tightened in harmony. That is, first tighten one a little and then tighten the opposite one just as much.

The Wrist Pin.—Should the wrist pin have caused the piston to wear, or better still, should there be any play other than side play between pin and piston the only way it can be remedied is to replace either pin or piston. The former is the easiest and cheapest, and necessitates the boring of the pin bearing to fit the new pin or the truing of the pin to fit the bearing. The latter is the simplest.

Loose Piston and Worn Cylinder.—These may be spoken of together, for in either event the piston will be loose. This necessitates the replacement of one part or the other. Replacing the piston is the cheapest and easiest, of course. This should be done by the factory for the piston must be "jacked in"; that is, ground to fit the cylinder perfectly.

Loose Flywheel.—A flywheel that has up and down play due to a worn bearing can be repaired

by rescraping or replacing the bearing. Should, however, the play exist between the flywheel and its flange, the nuts and bolts holding the wheel should be replaced or the old ones shimmed under. These bolts are usually sprung when the flywheel becomes loose, and require replacing. However, a shim between the flange and wheel may be satisfactory also. In any event the wheel must be removed.

Timing Gear Backlash.—There is no efficient method of decreasing the play between timing gears without replacing the worn gears.

Slaps.—A valve slap is usually remedied by turning the valve around while the motor is running. A certain position may be found that will seat the valve properly and eliminate the slap. However, if this is not successful the valve should be ground in. The push rod should then be properly adjusted.

The ring slap requires a little more pains, for the cylinder must be removed and a careful examination made of the piston rings, for those that display up and down play. If such a ring is found make a note of it for this may be remedied as will be shown later. Say, ring number so and so (counting from the bottom) has up and down play. The rings are then removed from the piston each one being marked with chalk telling from which slot it was removed, and from which piston.

Inspect the ends of the rings carefully and note if any metallic lustre appears. This is evidence that the ends have been rubbing against each other causing the troublesome slap. In any event the diameter of the ring should be measured with in-

side calipers. Place the ring on a flat surface, then measure the diameter of the slot from which it was taken and stretch or contract the ring until it measures this diameter. While in this position measure the distance between the ring ends with a thickness gauge and should this be less than the factory allows (usually .055 in.) file the ends until they show this distance. Find out what distance the factory allows between the ring ends, for filing too much may be harmful. To file properly the ring should be placed in a vise so that one end is free. A very fine file should be placed between the ends and the free end then brought in contact with the file. Then begin to file. This method facilitates getting the ends parallel. Do not file too much, but do a little and then remeasure the distance, continuing this alternate operation until the required distance has been filed.

Now any ring that may have developed up and down play may be thought about. Since the rings have been marked, showing their proper positions, it will not confuse one to interchange the rings. This should be done trying to fit all the rings in the slots perfectly. After trying many combinations and there still remains a loose ring it remains to get a new one. A new ring must be "lapped in," that is, ground to fit the slot snugly. To do this the ring is placed on an absolutely level metal surface that has been sprinkled with emery dust and water, making a paste. A block of wood is then placed on top of the ring to carry the ring back and forth on the lapping table. In this way the ring is ground.

Should the rings all be fitted, the cylinder wall

and piston should be carefully cleaned and oiled, before being replaced. The cylinder nuts should be tightened in the same way that the connecting rod nuts should be. This has been discussed in a preceding paragraph.

Push Rod Knocks.—If the faulty push rod is located, it of course, does not require the removal of all, but even so it will be well to remove all rod guides for examination.

A little play is always found between the rod proper and its guide, but .003 is about the limit allowed. A makeshift way to take up this play is to spring the guide by squeezing the ends lightly together, in a vise, just the least bit. This will make the guide loose in the crankcase, but this can be overcome by placing a piece of very thin metal around the guide at the top. The guide should fit tightly, but must be loose enough to be put in position by slight tapping with a hammer handle. Do not pound it in place. Other than this method, only the replacement of either guide or rod will cure the knocking.

Conclusion.—Should any knock whatever be heard coming from a motor, even though slight, the matter should be looked into immediately. Since a knock is caused by two parts hitting together, and since two things coming together cause rapid wear, it follows that the sooner the knocking is cured the less the parts will wear.

II.

CARBURETION.

Since the carbureter is a means of properly supplying and mixing gasoline or other fuel and air, it is evident that any carbureter trouble is due to too much or too little air or fuel being fed to the cylinders. In order to do its work properly the carbureter must permit the pistons to suck into the cylinders an explosive mixture, that is a mixture that contains the proper amount of sprayed gasoline and air. A mixture containing too much or too little gasoline acts similar to one containing too much or too little air. Such mixtures burn slowly and the flame sticks to the side of the cylinder. Now, as soon as the intake valve opens, the flame ignites the incoming gas with the result that there is pre-ignition. A good mixture explodes or burns very rapidly.

It remains then to cure curbureter trouble by properly proportioning the gasoline and air. As has been stated in the preceding pages, most curbureters have two air intake passages and one or more gasoline nozzles. One of the air passages is fixed, that is, the opening is constant and remains so while the engine is running. The other air passage, called the auxiliary or supplementary air and offers variable openings.

Let us take a motor which is missing fire and the cause determined as the curbureter being out of adjustment. There are two systems to follow:

one, to confine the attention to the air at first, and the other to look to the spray nozzle. Either is satisfactory. We will take up the method of testing the air. The first thing to do is to open the throttle about one-quarter, and then lightly press the auxiliary valve downward or inward as the case may be. Should the motor stop, then it is evident that too much air was being fed for the instant. Start the motor again and this time close the auxiliary air valve slightly. Not too much, but just the least fraction of an inch. The motor in this case may go faster. Should it do this, it is a clear case of the carbureter feeding too much air previously. If it does not, but instead slows down or stops then the nozzle should be looked to, the method to be described later.

Granting that the carbureter has been feeding too much air, the next step is to remove the auxiliary air valve. This valve is held in place usually by screws. With it removed, it should be examined to see just how far the valve is permitted to open. Press the spring downward as far as possible and measure the opening. Let the spring back and touch it lightly. Notice if it sticks. The object one should remember is to feed less air. To do this take the auxiliary air valve apart and stretch the spring slightly. Usually there is an inner spring which determines the extent of the valve opening. Stretch this a little also. Clean all the parts thoroughly. Fit the valve proper back into its place alone and notice if it moves freely. It should not stick at any point.

With the parts thoroughly clean replace them and then the entire air valve. Start the motor again and if it misses fire, ascertain by opening or

closing the valve whether it is getting too much or too little air. If too much then the springs were not stretched enough. If too little then take the valve out and compress the springs slightly.

However, if no air adjustment will help, look to the needle valve. No one knows just which way to turn the valve in order to prevent missing. However, black smoke at the exhaust is taken as an indication of too rich a mixture.

Close the valve just a little. If the motor speeds up, close it some more, in fact keep closing the valve, just a little at a time until the motor just begins to slow down. Then turn the valve back a little. The object is to get the motor running as fast as possible, idle, with a given throttle setting. If after closing the needle valve slightly the motor slowed down a little it is evidence that the needle should have been turned the other way, that is, open, so as to give the motor more gasoline. In turning the valve open, it should be done a little at a time until the motor is running as fast as it possibly can with the throttle unmoved.

Thus far only adjustments with the motor operating idle have been discussed. Often a motor will run perfectly when idle, but will misfire when pulling a load. The method then consists in stopping the car and either closing or opening the needle valve slightly. Try closing the valve, first. Close it slightly and then start the car. If the trouble is aggravated, stop the car and open the valve slightly. The writer cannot impress too strongly that it is almost impossible to tell from the seat just which way to turn the needle valve. One must try both ways and see which gives the best results.

In the Rayfield carbureter shown in Fig. 1 there are two fuel adjustments, one called the low and the other the high-speed jet or nozzle. The object of the low-speed jet is to give the proper mixture at low motor speeds and the other jet feeds the correct mixture for high speeds. The double jet is in use on a number of other makes of carbureters also.

Referring to Fig. 1, which shows the Rayfield carbureter and its various adjusting places, there

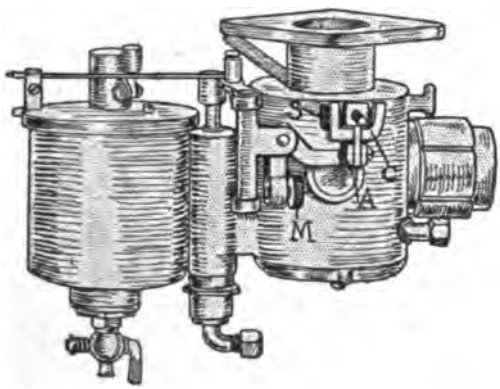

Figure 1—Adjustments of the Rayfield double-jet carbureter. The low speed jet is shown at M and the high speed jet at S.

is a dash adjustment and this is placed in neutral position. This is determined by observing that the cam is out of contact with the low-speed screw M. The screw is next loosened until the arm A begins to leave the cam C. At this point the screw should be turned to the right one and one-half turns. The next step is to adjust the auxiliary air valve, by unscrewing its exterior adjustable seat about ⅛ inch. The motor is started and

throttled as low as possible. The low-speed adjustment M is then turned until the motor will operate as fast as possible and smoothly with the throttle closed, in which position it was set previously. If the throttle does not close enough to permit the motor to run smoothly and slow, the throttle stop on the reverse side of the carbureter should be loosened a little. The throttle is now opened wide

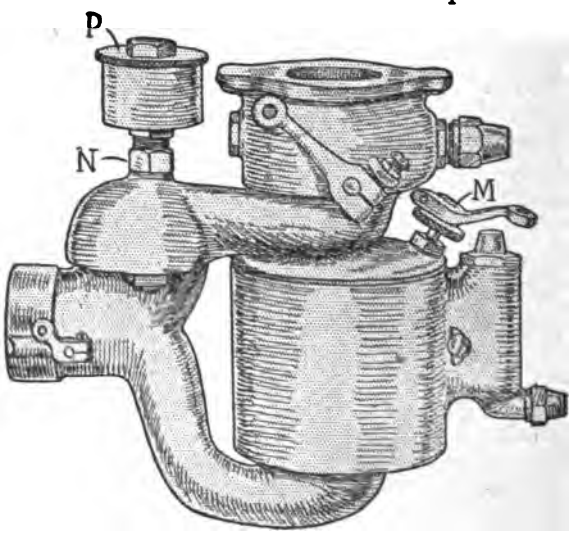

Figure 2—The Mayer, a distinctive type of modern carbureter using a dashpot air adjustment. P is the dashpot and N the adjusting nut.

so as to make the motor speed up and close suddenly. If the motor acts sluggish, give the high-speed screw S a turn to the right and keep turning to the right until the motor picks up quickly and easily. The car is then taken on the road and if the carbureter pops or "spits," as it is called, give

the high-speed adjustment S a turn to the left or right. First try one way and then the other.

There is one type of carbureter in the market which is unlike many of the rest. It is the Mayer and is illustrated in Fig. 2. The air valve on this type is called a dash pot and its adjustment, although giving the same result is different from that described above. To adjust the Mayer the following method is employed: To give the carbureter more air the nut N is loosened and the

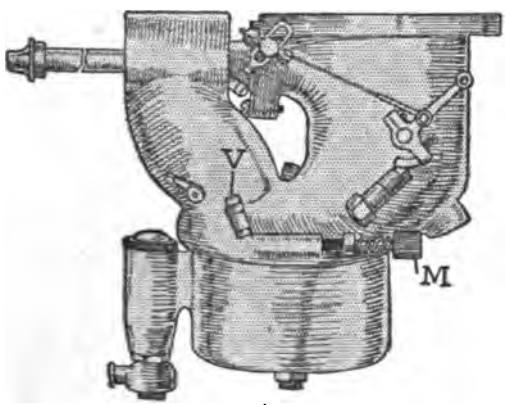

Figure 2—A carbureter of simple adjustment is the Marvel shown above.

dash pot P turned to the left very slowly until the point is reached where the motor will operate its fastest. In getting the maximum speed with a given throttle opening by giving less air, turn the dash pot P to the right slowly. The needle valve adjustment on the Mayer is shown at M. When this is turned to the right less fuel is fed and when to the left more fuel.

If after adjusting the dash pot both right and

left without good results try adjusting the needle valve. In making any of these adjustments do not turn too much or too quickly.

Another make of carbureter which is in common use is the Marvel shown in Fig. 3. This is in use on a great number of small cars and the method of adjustment quite simple. The needle valve V should be turned to the right as far as possible and after that turned to the left two turns. This gives the carbureter its initial needle valve setting.

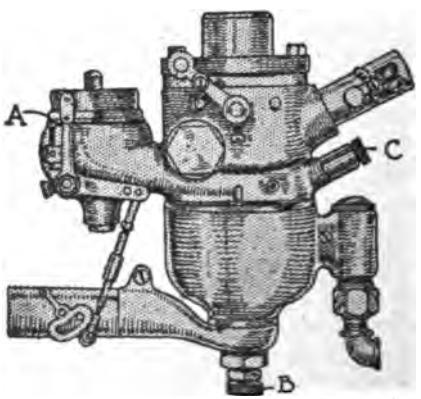

Figure 4—The Schebler carbureter, Model O, showing its various adjustments.

The air adjusting screw M should be backed out or turned to the left until it just stops and then turned back or to the right three turns. This is the initial air valve setting. With these adjustments the motor should be started and the throttle opened about one-fourth. Then close the throttle slowly and get the motor operating as slow as possible. Turn the needle valve M to the left until the motor runs at its maximum speed with the throttle closed. If the motor stops when the valve

is turned, start the motor again and turn in the opposite direction. The object, as previously stated, is to get a state of affairs where the motor will run as fast as it possibly can with the throttle very nearly closed. With such a setting the maximum power is obtained from the fuel and the consumption of gasoline as small as possible.

The Schebler carbureter model 0, is shown in Fig. 4, and its method of adjustment follows: First be sure that the auxiliary air valve is seating lightly. This can be ascertained by pressing on the valve with a pencil. Then close the needle valve B and the nut C all the way, but do not try to turn too much. When resistance is felt, stop turning. Then turn the needle valve B to the left three turns, open the throttle and start the motor. Then turn the needle valve to the right until the motor operates smoothly with the throttle nearly closed. Open the throttle about one-fourth and if the motor pops, screw down on the screw A until the popping stops.

The nut C is designed to operate the high-speed jet which does not come into action until the car is traveling at about 25 miles an hour. With the low-speed adjustments made the next step is to open the high-speed jet about two turns and start the car. If at high car speed popping is heard, open the high-speed jet a little more and so on until the motor runs smoothly and on all cylinders, at high speeds.

The Stromberg, type C, carbureter is another of the double-jet type and is illustrated in Fig. 5. The low speed adjusting screw L should be turned up or down until the spring which this controls,

makes the valve seat lightly. After this has been done the screw should be given three more turns upward. The valve controlled by the screw should begin to open when the motor is running at about 500 revolutions per minute and not before. The adjusting screw L is known as the low speed adjustment. The high speed adjustment is shown at H. The nut H should be about 1-16 inch above the small lever shown. Should the motor misfire

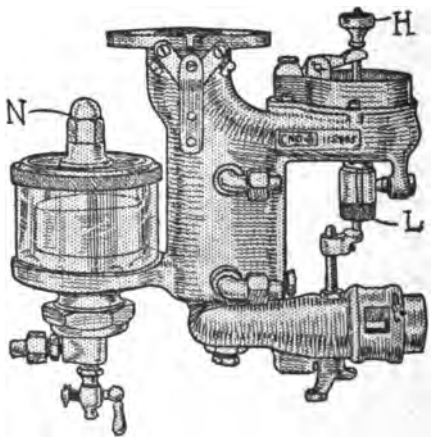

Figure 5—Visible float Stromberg carbureter showing the low speed adjustment L and the high speed adjustment H.

at high speeds, turn the nut up or down until the misfiring stops. It hardly is necessary in this make of carbureter to adjust the needle valve N, but should the other adjustments not cause the motor to run properly, the needle valve N should be raised or lowered until the proper mixture is obtained. By turning this nut downward the mixture is made leaner, and by turning it upward

a richer mixture is obtained. In this and all other carbureters make the adjustments slowly and permit the motor to operate a few minutes each time an adustment is made.

The methods of adjusting the distinctive types of carbureters have just been described, but very often it is not always poor adjustment which causes a carbureter to act poorly. A very common complaint is water or dirt in the fuel. Dirt is more harmful than water for the former will make its way to the needle valve and clog it up, thus preventing the fuel to flow freely to the mixing chamber. It is good policy to remove the gasoline line once each year and clean it out thoroughly by passing a current of air through it. Get the air from the tire pump. The gasoline should always be strained through chamois preferably and then there will be little chance of any dirt or water entering the tank.

Quite often air leaks about the intake manifold and cylinder plugs will cause the motor to misfire and the carbureter is blamed. The gaskets between the intake header and cylinders should be in good condition always and especially when the header is being replaced should this gasket be examined. It is best to use a new gasket every time the header is put back on the motor.

In a number of instances cork floats which are used in carbureters become gas-logged, as it is called, that is, they become so saturated with fuel for such a long time that they no longer float, with the result that the motor may not operate at all.

III.

IGNITION.

Whenever a motor starts misfiring the owner of the car usually places the blame on the magneto. These instruments give such little trouble nowadays with so little care that one wonders how they do their work so efficiently. In making such in-

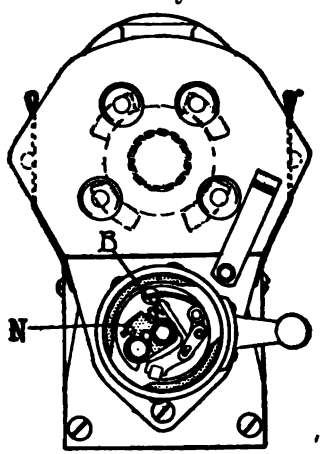

Figure 6—View of Bosch magneto, showing the breaker points B and means of adjusting N.

struments the manufacturers have endeavored to make them "foolproof."

The most common magneto ailment is due to the interrupter or breaker points being poorly adjusted. These points are designed to make and break the primary circuit and if improperly ad-

justed may cause the magneto to fail. In Fig. 6 is shown the location of the breaker points B on a Bosch magneto. These points continually make and break and in order to do their work properly they must be perfectly flat and smooth and when fully open should be about 15 thousandths of an inch apart. To determine this turn the motor over slowly until the points are fully separated and then insert between the points cardboard, or better still, a thickness gauge to determine the exact distance between the points. Should they be too far apart or too close together there is an adjusting nut provided for moving the points. By moving

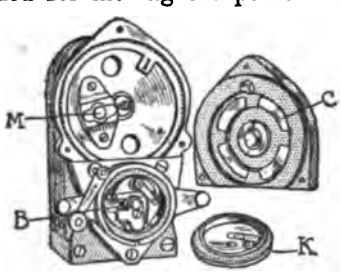

Figure 7—Simms magneto with distributor cover and breaker box cover removed. Dirt on the segments C often causes misfiring.

the jut N in Fig. 6, the points may be brought together or made to separate farther. After the adjustment has been made, place a few drops of kerosene upon the points. This should be done at least once each month to keep the points free from gummy substances for these tends to short circuit the points and thus prevent the breaking of the primary circuit. The method of removing and resetting this and other magnetos will be taken up later.

In Fig. 7 is illustrated the Simms magneto, type SU4, with the object of showing the location of the troublesome parts of the magneto. The distributer arm M revolves and as it does so it makes contact with the segments C on the distributer cover. Should this arm or the segments be dirty the result may be that the current will not flow and hence the cylinder will not fire. It is a wise step to examine the distributer arm and the segments a few times each year to see that they

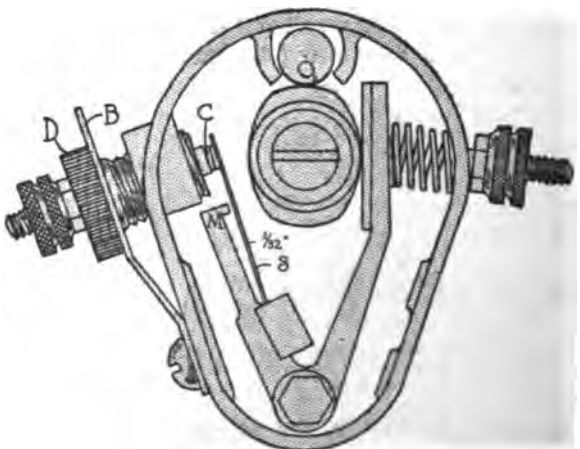

Figure 8—Breaker mechanism of the Remy magneto. The space between the arm M and the flat spring S is 1/32 inch at the end of the arm M.

are perfectly clean. They should be wiped with a clean cloth and then oiled. A few drops of oil is sufficient. The cover K of the breaker box removed shows the breaker mechanism and the breaker points B. As before stated these points must be adjusted properly and clean, before the magneto will do its work well.

The breaker mechanism of the Remy magneto is shown in Fig. 8. When the cam is in the position shown the flat spring S should be separated at the place indicated, by 1/32 inch from the arm M. The platinum points C should be clean and when separated there should be a space about 15 thousandths of an inch between them. The points are adjusted by pressing down on the bronze spring B and then turning the hard rubber screw D either to the left or right as the case requires. Should the motor misfire with the spark retarded and while running at slow speed the screw D should

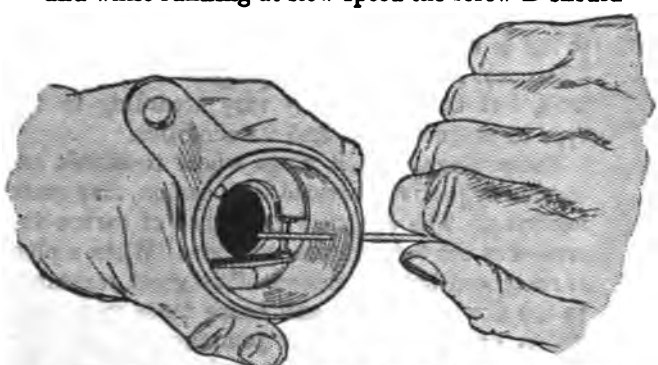

Figure 9—Filing the platinum points of the Connecticut magneto. The breaker box is fitted with a small hole for the introduction of a file.

be turned to the left a quarter turn. If the motor misses with the spark advanced and the motor running at high speed the screw should be turned to the right a quarter turn.

Should the breaker points of the magneto be uneven they should be filed flat with a very fine magneto file. A fine nail file will do just as well. In the Connecticut magneto the filing is made easy

by the introduction of a filing hole in the breaker box as shown in Fig. 9.

Much ignition trouble is due to improperly adjusted or dirty spark plugs. If the electrodes of the plug are too far apart or too close together misfiring may result. In the former case the voltage of the magneto current is not great enough to jump the gap and in the latter the gap is so small that the spark produced is of insufficient density to ignite the gas. Some owners look to the plugs as soon as the motor starts to misfire and this procedure is not at all wrong, for plugs, are liable to fail in more instances than the modern magneto. The usual gap at the spark plug terminals is 1/32 inch, but this figure may vary according to the type of magneto used and its condition.

Sooty plugs, that is plugs whose terminals are covered or partially covered with carbon, may cause misfiring. The electrical resistance of carbon increases as the temperature increases. When a plug is sooty and hot the carbon offers great resistance to the flow of current and hence there is a probability of the spark never jumping the gap and thus causing that cylinder to misfire. Again, the soot on the plug may become incandescent and remain so for a while, and as soon as the intake valve opens it will ignite the incoming gas and cause a premature explosion. Sometimes plugs become so sooted as to short circuit the terminals. That is, the soot covers up the gap in the plug and in this case no spark will occur.

In four unit coil ignition such as the Ford uses the improper adjustment of the coils on the dash will cause missing. On top of each coil is a

platinum vibrator and should this vibrator become out of adjustment the cylinder with which the coil communicates will misfire. This adjustment should be such that the cylinder will properly fire and yet not cause arcing at the points. Continual arcing may result in the burning of the points. All connections from the coil boxes should be tight and clean.

Many car owners are afraid to remove the magneto for cleaning or inspection believing that it is a difficult matter to replace it properly, but a few simple instructions will enable one to do this work without confusion. The first thing to do before removing the magneto is to note in which direction the breaker box is set when the spark lever is in retard position. This is needed later. Let us suppose that the magneto has been removed and placed on the bench. Remove the distributer and breaker box covers. Turn the armature shaft around until the distributer arm is on segment No. 1 and at the same time have the breaker points just separating with the box in retard position. Get the points separated and then turn the armature shaft back so that the points touch. The magneto is now ready to send a spark to cylinder No. 1. The next step is to get cylinder No. 1 ready to receive the spark. Turn the motor over until No. 4 exhaust valve is fully open, and both intake and exhaust of No. 1 closed. The flywheel at this point should be on or very near dead center. No. 1 cylinder is now ready to receive the spark and the magneto may be slipped into position.

Not long ago a man entered a repair shop with

his car and complained that there was wax running all over the wiring and that the wax appeared to be coming from the coil behind the dash. He claimed that the motor misfired. His trouble was easily ascertained. The switch was left on battery side and the heat generated by the current caused the condenser wax to melt and run out through the bottom of the box.

IV.

VALVE TROUBLES.

When valves become pitted, or when they are poorly adjusted trouble is bound to ensue. Valves, to do their work properly, must open and close at certain periods and when they do close they must seat fully. Should the valve be pitted, the effect will be that there will be a leak when the valve is closed. A particle of carbon imbedded in the valve face causes the valve to seat improperly, with the result that when supposedly in the closed position, the mixture from the carbureter, in the case of the intake valve, will flow into the cylinder. Thus a premature explosion may take place.

The usual method of determining whether the valves are not seating properly is to ascertain if the compression is good. This is done by turning over the motor until resistance is felt. This should be done with each cylinder and should the resistance of one cylinder be less than that of another it is a sign, usually, of an improperly seating valve in the cylinder with the poor compression. But it should not be taken that only an improperly seating valve causes poor compression. Cylinder plug leaks, insufficient clearance between the valve and valve tappet also will cause this condition, so it remains to see that these are corrected. The first thing to do in regrinding valves is to get the proper material and tools together. Ordinary grinding compounds bought in the supply store

consist of emery dust in various grades mixed with oil. Ground glass and oil is very good, but only when the valves do not require much grinding. It is good for finishing which will be described later. The other necessary equipment is a valve grinder, or if not at hand an ordinary screwdriver will do, and a small light spring such as used on the air valves of carbureters. A little cotton waste completes the equipment.

The valve springs are removed, together with the cylinder plugs above the valves and then the

Figure 10—Method of valve grinding using a screwdriver. Note the cotton waste which protects the cylinder from the entrance of dirt.

valve itself. One cylinder should be worked upon at a time. The entrance to the combustion chamber should be plugged with cotton waste or cloth to prevent any of the grinding compound or dirt making its way to the cylinder wall.

Turn the motor over until the valve tappet is in the closed position, for otherwise the valve will

not seat when grinding is being done. Every time a valve is ground, the motor should be turned over until the tappet is in closed position.

The next step is to place a little of the coarse grinding compound on the face of the valve. This is done with a knife. Then place the light spring over the valve stem and put the valve in its usual position in the motor. If a screwdriver is used as shown in Fig. 10 it should be placed between the palms of the hands as shown and the hands rubbed back and forth so that the valve turns only half way around each time. Slight pressure should be exerted on the spring so that the valve face touches the seat. Each turn of the valve the pressure should be released for a second. This operation should continue for about two minutes and then the valve removed and cleaned thoroughly in gasoline. If the face appears an even gray color throughout then no more grinding is necessary, but if there are little black spots on the face, grinding should continue. This time use the fine grade of emery or the ground glass previously mentioned. Keep grinding with this substance until the face of the valve is of the same gray color throughout.

The operation of grinding should be done to all valves, both intake and exhaust, and it will be found that compression will be better and the motor gives much more power.

Weak valve springs often give much trouble. When a valve spring is weak, the valve will not seat properly and one may think that the cause is due to a pitted face. The spring should be taken out and stretched slightly and then replaced. Sometimes a spring may be stretched a number of times

but still the valve will not close. This is due to the spring temper being poor. Excessive heat around the valve spring usually causes this. Such springs may be retempered by heating them to a cherry red heat and while in this condition plunging them in fish oil.

Poor tappet adjustment is another ailment which should be watched. When the tappets are poorly adjusted the valves open either too soon or too late, as the case may be. In adjusting the tappets a clearance should be just enough to permit an ordinary business card to be slipped between the tappet and valve stem. The exhaust valves should be given a little more play as they become hotter and expansion at the tappet is greater.

IV.

FITTING PISTON RINGS.

So much is dependent upon piston rings that care should be taken in fitting them to the piston. If poorly fitted, either too loose or too tight, the results when the piston is in the cylinder may be harmful. Loose rings cause a loss of compression and permit oil to get above the piston and thus hasten spark splug fouling and carbon deposits.

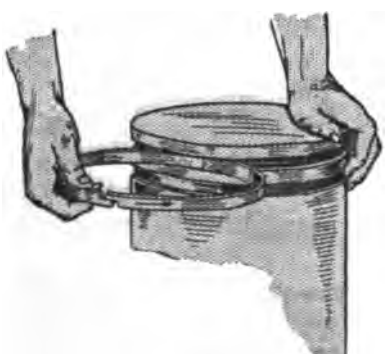

Figure 11—Giving a piston ring its initial fitting. The ring is turned in the direction of the arrow.

In fitting rings, the first procedure is to get grooves in the piston perfectly clean. With the grooves clean, the next step is to give the rings their initial fitting. The method of doing this is shown in Fig. 11. If the ring will not go into one groove try another groove. In giving the initial

fitting always fit the back of the ring first as the illustration shows and then move the ring around in the direction of the arrow until the entire ring has touched the groove. If there is no ring that will fit any groove then the ring must be lapped-in, the method to be described later. After the initial fitting the ring should be inserted into the cylinder to determine whether the ends of the ring are the proper distance apart. They should not touch when in the cylinder, but the space should be about .015 inch. This figure varies with the different makes

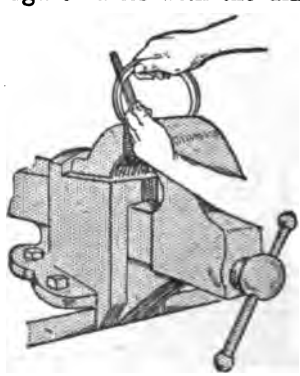

Figure 12—Filing the ends of a piston ring to prevent a ring slap.

of motors. If the ends touch they should be filled, as shown in Fig. 12.

The next step is to make the ring fit the groove perfectly. This is done by lapping-in the ring. For this operation a perfectly flat surface must be used. A surface plate is used at the factories. Upon the plate is sprinkled some fine emery and enough water added to give it a pasty consistency. The ring is then placed on the plate and over the

ring is placed a block of wood. Grasping the wooden block with both hands the ring is drawn back and forth over the plate. If the ring will not stay under the wood, cut a little groove in the block so that the ring may take hold. After lapping, as this operation is called, for a few minutes remove the ring and clean it thoroughly in gasoline and then fit it into a groove. Try the groove which it nearly fitted before. If the ring fits the groove by the method shown in Fig. 11 then it should be placed to one side and marked showing the groove and piston to which it was fitted.

Figure 12—Slipping piston ring over the top of the piston. The ring should not be spread more than necessary.

When all the rings have been lapped-in and numbered showing the position they will occupy, the next step is to place them on the piston. The bottom ring should be fitted first. Fig 13 shows how the ring should be placed in its groove. When it is in position, grasp it with all the fingers of one hand and turn it around. It should move freely and yet there should not be any play up or down. If there is, too much lapping has been done. If it

is tight and cannot be turned around it should be removed and lapped a little more. If it is a good fit, the ring on top should be placed in position and the same test made.

The method of removing a ring is shown in Fig.

Figure 14—Removing rings by the use of pieces of old blade as tracks.

14. Two or three pieces of old saw blade are forced under the ring at its ends and then the pieces pushed around as shown. The ring is then slid off on the blades, acting as tracks.

VI.

TIRES.

THEIR AILMENTS, CARE AND REPAIR.

Aside from gasoline the greatest expense in the upkeep of a motor car are the tires, and much of the present excessive tire wear may be reduced by the owner if a reasonable amount of precaution and care are given. There are ten common tire diseases, which are due to wheel out of alignment, under-inflation, use of anti-skid chains, skidding, running wheels in car tracks, neglect of casing repairs, tread cuts, running in ruts, stone bruises, use of inside protectors on new tires. These will be taken up in order.

When a tire is on a wheel which is out of alignment, the result is that the tire is scraped across the surface of the road and the resulting friction causes the tire tread to wear rapidly. The action of the tire on the road is crosswise at the same time that the tire revolves with the wheel. Thus the tire receives its usual wear plus the wear due to the scraping. The tread of a tire which has been run on a wheel out of alignment presents a rough appearance, that which would be given it were the tire held against an emery wheel for a while. Sometimes the fabric shows in places and this is especially true of wheels which are wobbly. It is evident that since an out of alignment wheel causes excessive tire wear, that the wheel should be looked after. It is advised by most engineers to line up

the wheels of a motor car about every three months, and if one is found which does not run true, the condition should be corrected immediately.

Perhaps as much harm is done by running a tire under-inflated as by anything else. Under-inflation, as the name implies, means that the tire is running with insufficient air pressure. Such a tire appears usually with a series of hilly blisters running around the tread. The blisters are caused by the separation of the fabric from the tread due to the excessive heat generated in an under-inflated tire. With insufficient air the flexing of the walls of the tire causes heat to be generated and this heat acts on the cement between the tread and fabric and in a short time the two separate causing a blister to appear. Even in the summer a tire should not be run under-inflated as many owners imagine. The common version is, that if the ordinary pressure is 80 pounds, a reduction of possibly ten pounds is made for summer weather. The belief is that the heat of the atmosphere will soon raise the temperature of the air in the tire and thus cause the pressure to increase to the proper point. This practice is not advisable, as there is undue wear on the tire while the pressure is being increased by the rise in temperature and also because the pressure will drop as soon as the tire cools. The cure for under-inflation need hardly be stated. Keep the tires inflated to the pressure specified by the maker, which is usually 20 pounds per inch of cross-section. Thus a 4-inch tire should carry 80 pounds' pressure. It matters not if the pressure is a little more, but it does

if the pressure is less than that for which the tire is designed. A tire gauge, such as is sold for one dollar, should be one of the important instruments in the motorist's tool kit.

When anti-skid chains are applied to the tire too loosely or too tightly, the result sometimes is a cut tread. These chains should be placed on the tire so that they fit snugly and then no material tire wear will result.

Running a wheel in car tracks may soon cause the sides of the tire to become chafed, and in some instances the wear is so much that the tread loosens at the sides and begins flopping around. The same appearance may result if the car is driven very close to the curb and the side of the tire made to scrape the stone.

Little cuts in the casing often result in the casing being unfit for use in a short time. When a small cut appears and the tire is operated, dirt and water is permitted to get underneath the tread. This dirt works its way around the tire under the tread with the result that the tread is soon loose. Water, as everyone knows, is detrimental to rubber and more so to the fabric. Fabric begins to rot in the presence of water. The small cuts may be plugged with mastic.

Often a cut appears in the tread and an inspection finds that the fabric is injured also. In such an instance the blowout patch is the first resort. The patch, if wrongly applied, sometimes becomes wedged in the fabric cut and in this way hastens a blow out. The best way to treat a tire with a reasonably large tread cut is to have the cut vulcanized immediately. In fact, even when small

cuts appear these should be vulcanized at the first opportunity. The owner may say that the cost of having the tire vulcanized every time it is cut is expensive. It may seem expensive at first, but the saving in tire wear and repair later overbalances the comparatively small cost of vulcanization.

In the fall especially country roads present a mass of hardened ruts which play havoc with motor car tires. These hard indentations house the tire for a while and then the driver will go over the rut. The driving in and out of these ruts creates a condition which puts a tire in the rut-worn class. The sides of the tread begin to show rapid wear and sometimes the wear is great enough to cause a weak spot in the tread with the result that the tire blows out.

Stone bruises are said to cause a great percentage of tire failure. When a tire runs over a stone, one as big as an ordinary man's fist, there is a possibility of the fabric becoming broken. A broken fabric soon causes a blow out, so it remains for the driver to prevent as far as possible running over such stones. The smaller stones sometimes present sharp edges which cut the tread and thus make an entrance for dirt and water. Stone bruises are hardly visible from the outside, as the condition is one of a fabric break as mentioned above. The result of a stone bruise may be seen by examining the inside of the casing, which will show clearly that the fabric is injured.

Some makers state that the use of inside protectors on new tires is not advisable, as these appliances create an undue amount of heat in the tire and thus hasten wear. For old tires the inside

protector is perhaps the best accessory marketed for lenghtening tire life. Some owners have obtained as much mileage with old tires and inside protectors as they have from new tires operated without protectors.

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